Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

SEPTEMBER 1949

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PP9-4

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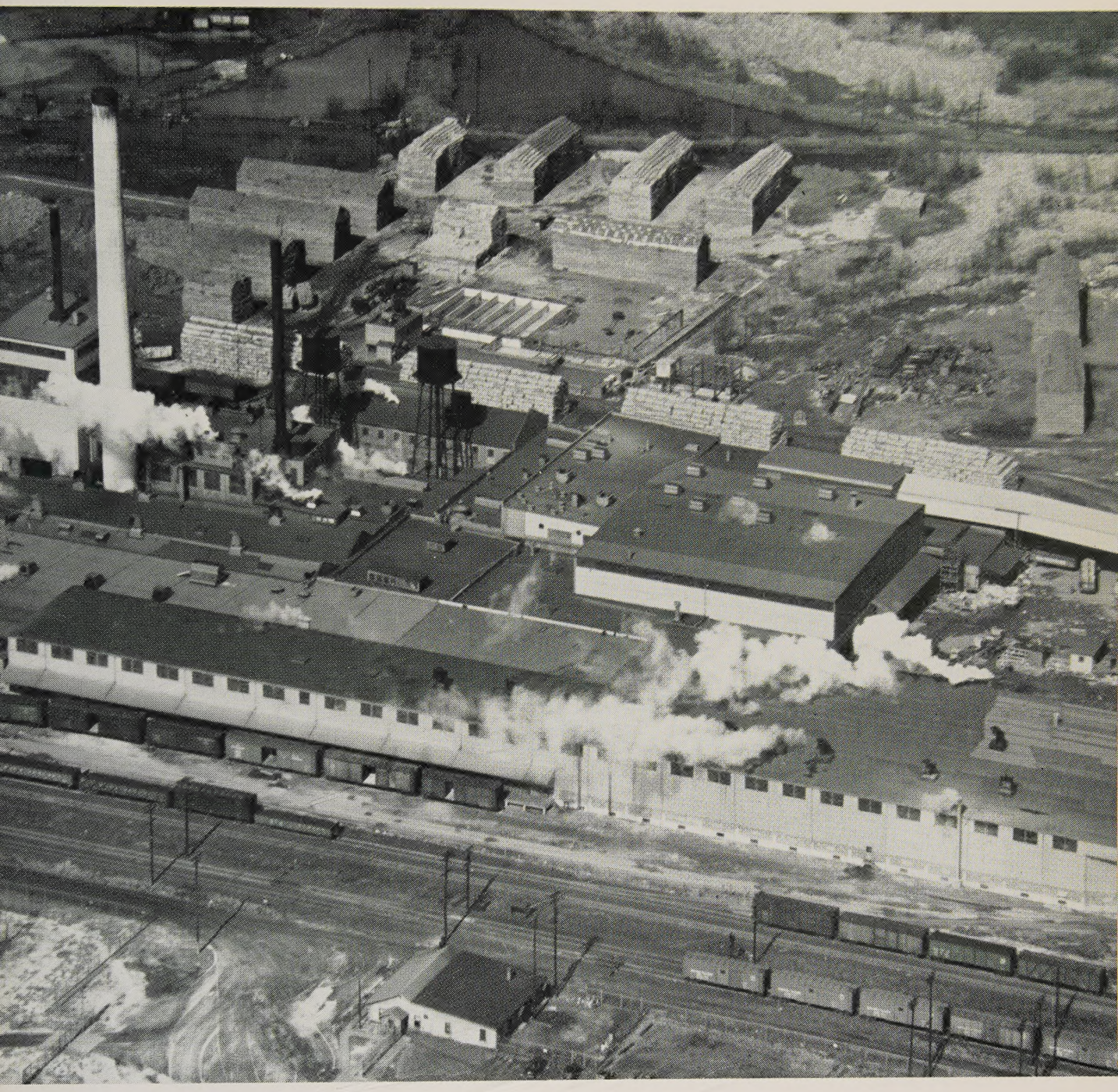

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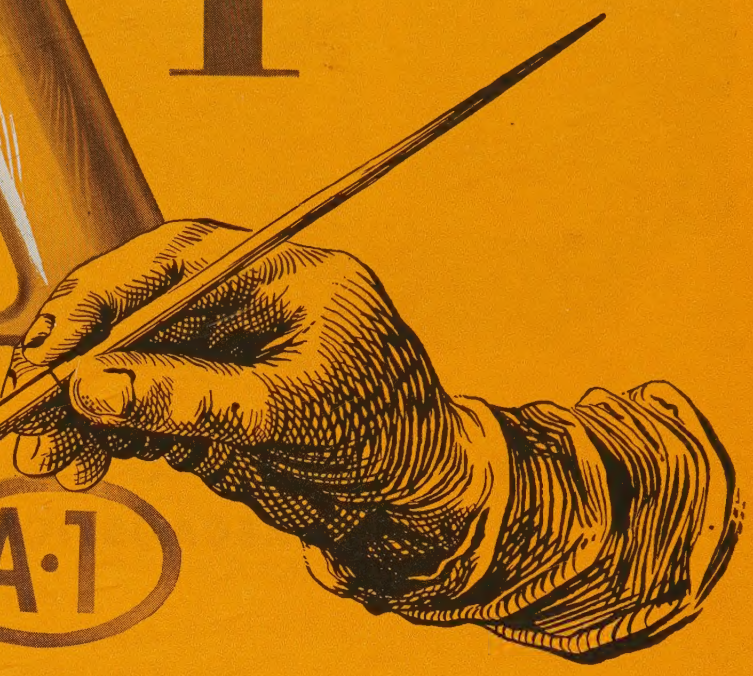
certify: to make known or establish a fact

A1

A-1



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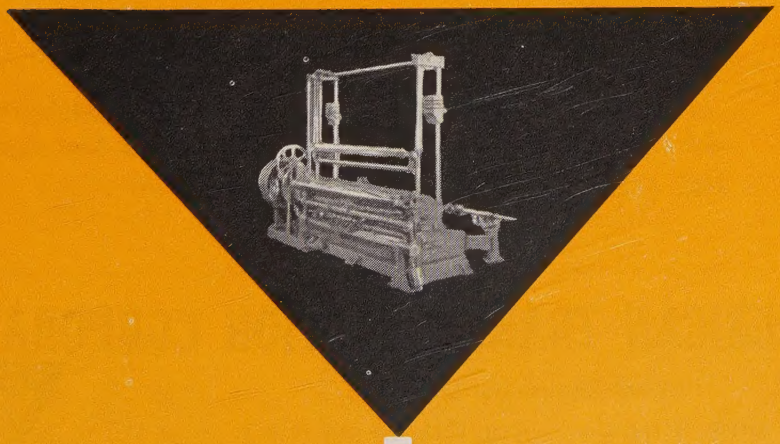

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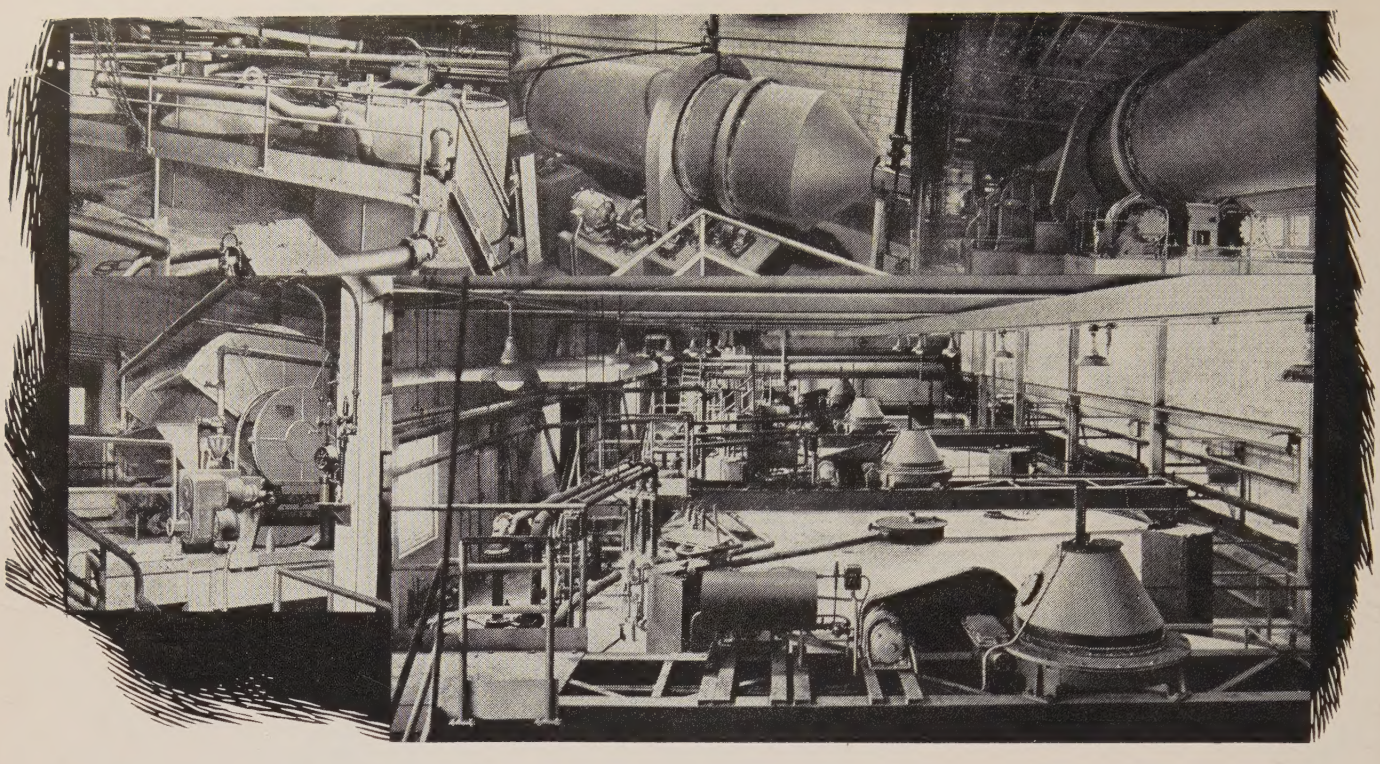

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SEPTEMBER 1949

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The Secret Born in a Darkroom

In 1802 two Englishmen—Thomas Wedgwood and Sir Humphry Davy—published a paper that was to make history. They described how, in a darkened room, they had made profiles by casting shadows on paper moistened with nitrate of silver. But when exposed to light the silhouettes soon disappeared. Not until 1835 did another Englishman, W. H. Fox Talbot, devise a way to make a photographic image permanent. And it was more than a half-century later that George Eastman introduced his first small hand-held camera, followed it with transparent, flexible roll film and special papers, and made photography available to all.

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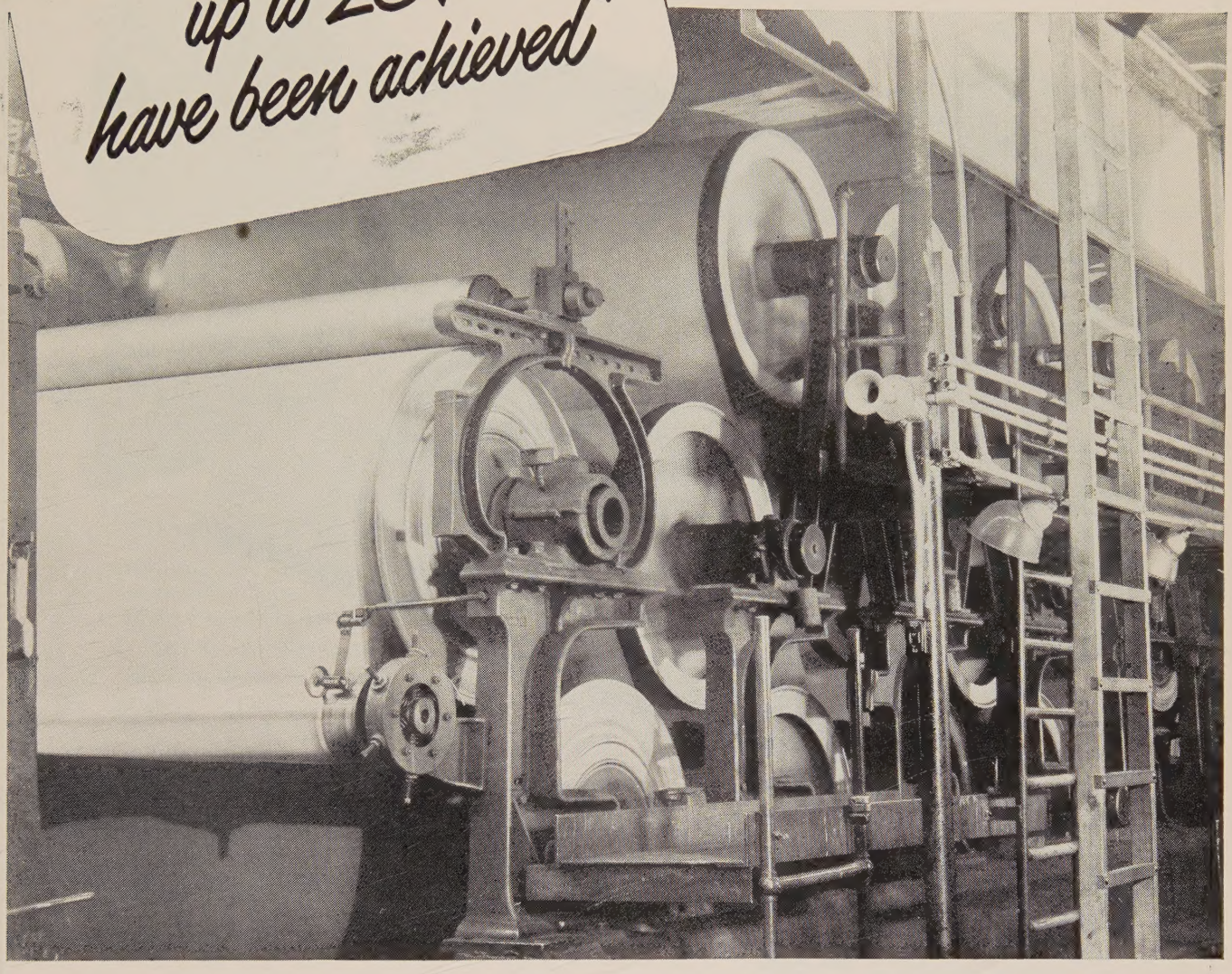

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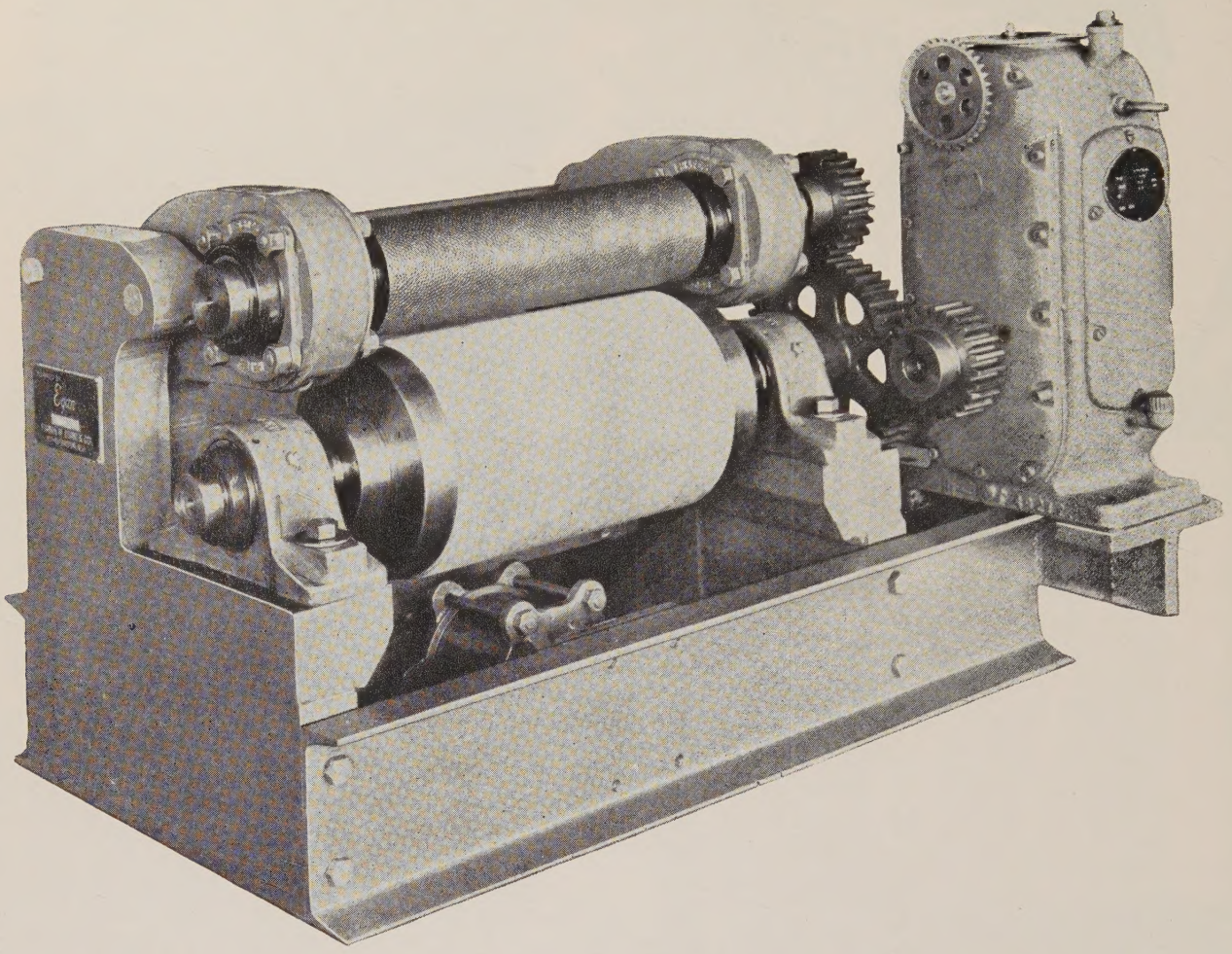

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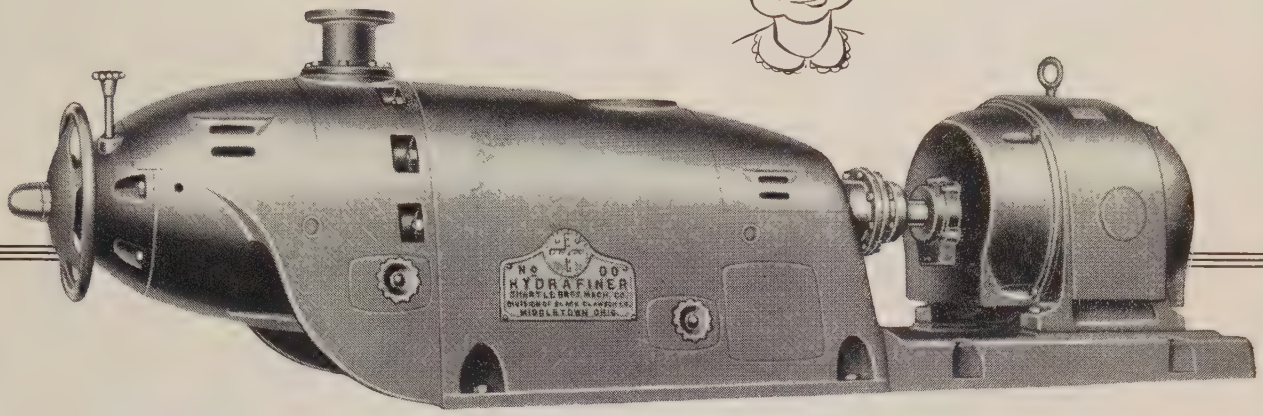

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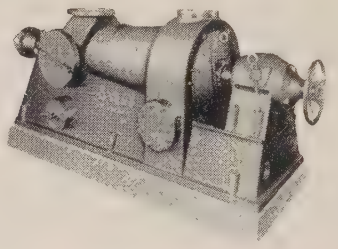
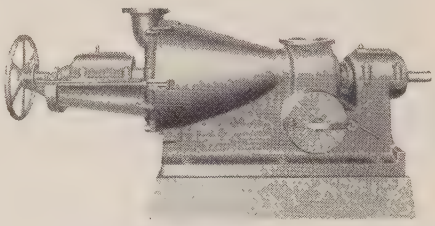
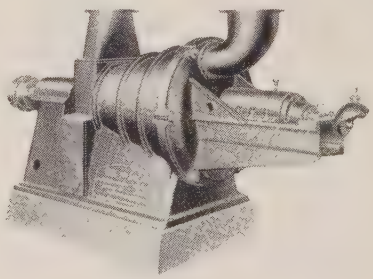


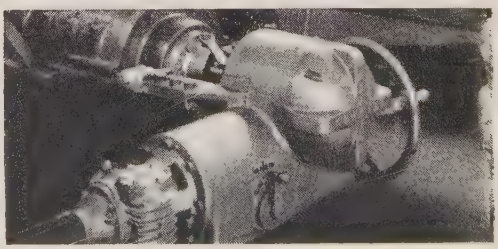
No. 1 Capacity range: practically all grades, and depending on treatment desired—10 to 30 tons/24 hrs.



No. 4 Capacity range: practically all grades, and depending on treatment desired—15 to 40 tons/24 hrs.



No. 6 Capacity range: practically all grades, and depending on treatment desired—30 to 150 tons/24 hrs.



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Name:_____*

Equipment: One 30' dia. Dorrco Clariflocculator.
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Feed: White water from paper mill. Solids contain 17–74% clay, starch, titania and other coating materials.
Chemicals Used: Paper Makers' Alum and activated silica.

Test No.	Solids—lbs./1,000 gal. Feed	Effl.	Sludge	% Recovery	Sludge % Solids
1	8.38	0.16	35.69	98.5	0.43
2	6.57	0.16	43.82	97.8	0.53
3	3.90	0.16	28.39	96.3	0.34
4	5.40	0.16	25.98	97.6	0.31

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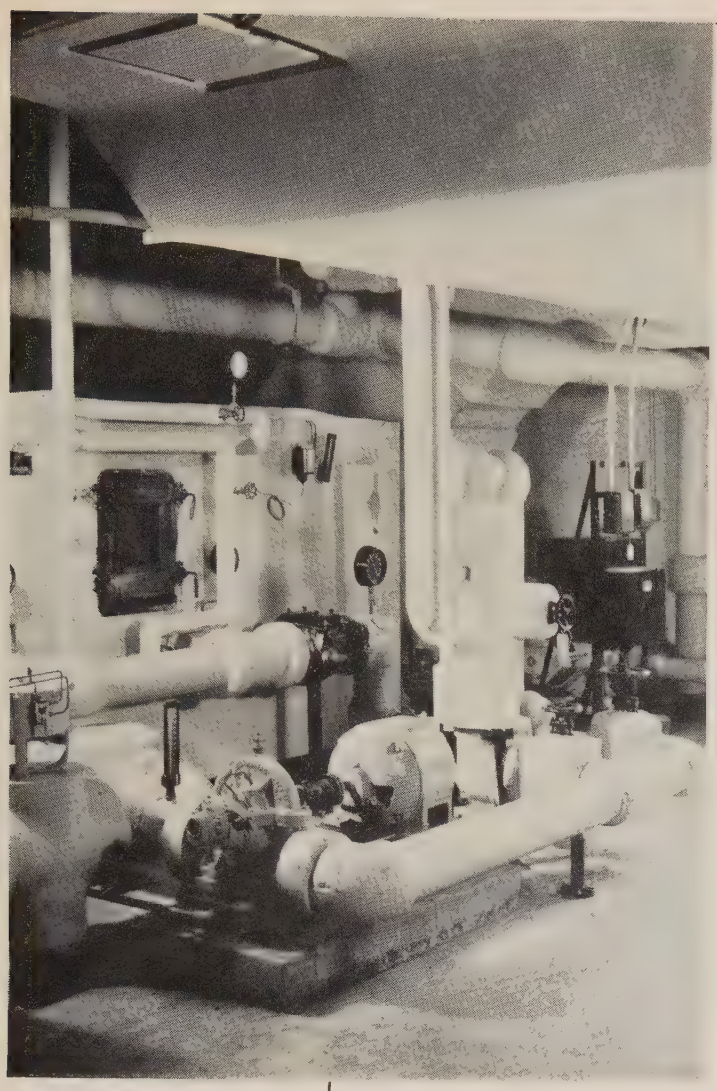

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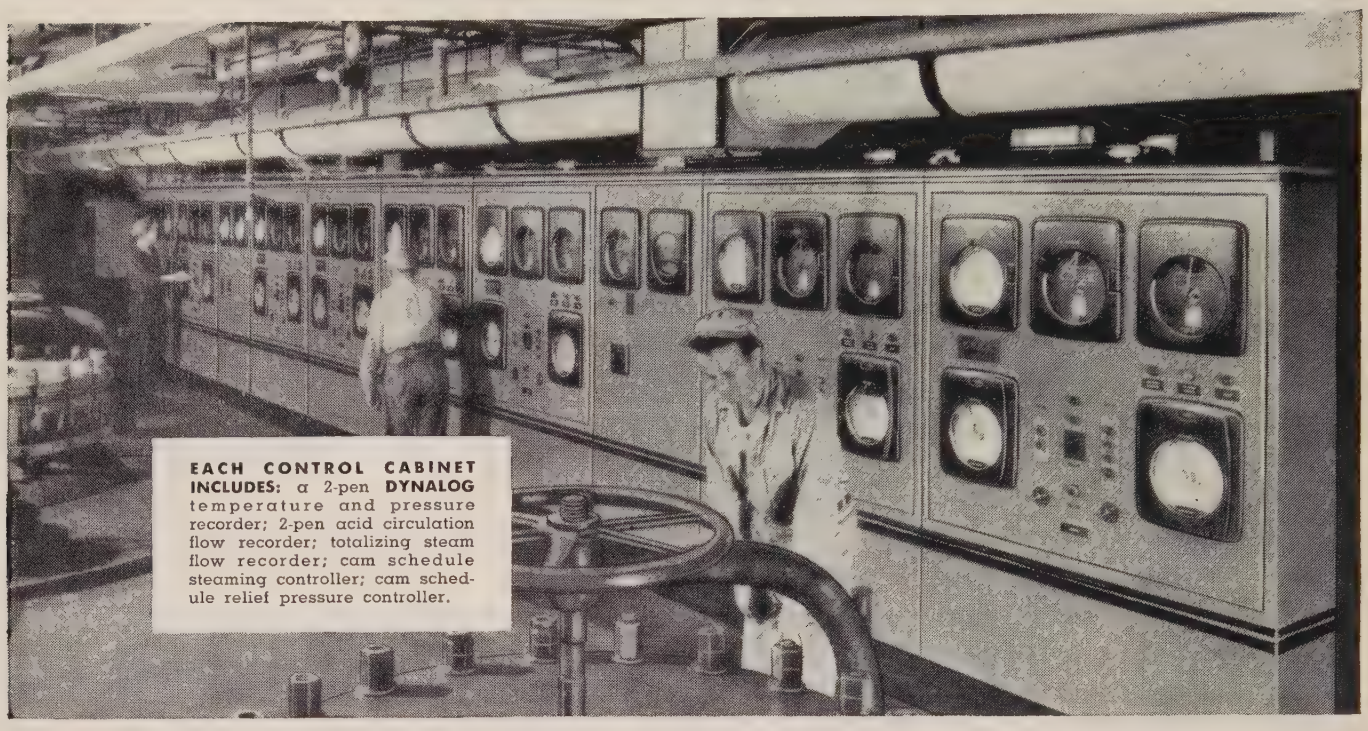

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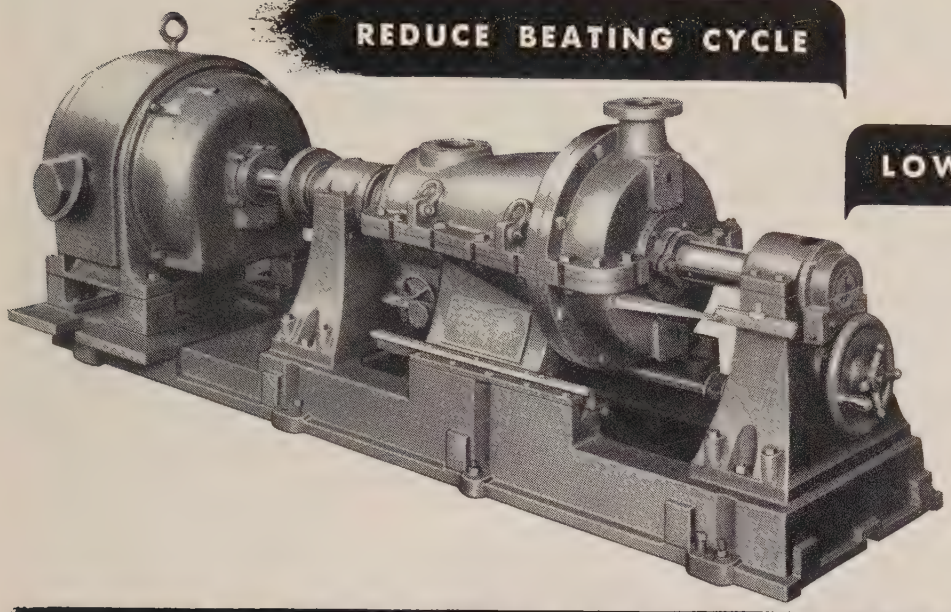

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MARATHON IN CANADA

Ferdinand Kraft

A LITTLE over two years ago operations were started in one of the finest sulphate mills in North America. This plant was erected in Canada by the Marathon Corporation during the war and the period following it, with a definite objective in mind.

For considerable time concern had been felt by many American pulp consumers as to the dependability of their chief raw material source. In particular, paper and converting mills located in the eastern and central states observed with anxiety the depletion of the coniferous wood resources in their parts of the country. Marathon, who are heavily engaged in the manufacturing of food packages and similar products, recognized the advisability, if not necessity, of securing for itself a supply of suitable wood pulp from which the converting plants could be fed, irrespective of any future market conditions and the instability of European supply sources.

Wood in sufficient quantities to sustain a new production unit is found on this continent today only in Alaska, the south, and perhaps on the west coast, all districts which are quite distant from Wisconsin. It was, therefore, very fortunate that one of the few remaining limits in Ontario could be acquired on the north shore of Lake Superior along the Pic River, only about 300 miles from here (Appleton, Wis.) as the crow flies.

These limits contain good Canadian timber, predominantly spruce with some jackpine and smaller quantities of aspen. Peninsula Harbor, near the mouth of the Pic, furnished a site for the mill and town and has the advantage of providing for transportation by water, goods to the plant and finished pulp to the mills of the parent company (Fig. 1).

FERDINAND KRAFT, member TAPPI; Technical Director, Marathon Paper Mills of Canada Ltd., Marathon, Ont.

Fig. 1. Map showing location of Marathon, relative to mills of parent company

Fig. 2. Slasher mill and barking drums

The selection of this site was decided upon only after a detailed survey of its natural advantages had shown that they outweighed possible shortcomings.

Generally, without including special industrial features, the most important factors to be thus valued are: Cost of raw materials, labor, fuel, water and power supply, living and transportation conditions, cost of maintenance supplies, taxes, legal requirements, and cost of construction.

It was thought that it might interest you people to hear a little about this new plant and its equipment, and also about the town which was built at the same time and is today the home of about 2500 people.

Wood Handling

In spring, the wood comes down the Pic River and is towed from there eight miles to the mill in large bag booms. Experience has shown that the mixture of the various species is just about right for producing pulp of the desired quality and no segregation has been attempted. A compactly designed slasher mill reduces the 12-foot bolts to 4-foot pieces which are immediately dry-barked in three 12 by 45 feet Horton barking drums of the suspended type (Fig. 2).

This dry-barking is quite efficient and has been operated continuously at a rate of some 1400 to 1500 cords per day. During the barking season the mill is supplied with wood from the Lake, the remainder being stored in five piles. One of these piles will later on be reserved for deciduous wood and further separation can be accomplished if desired. It is perhaps worth mentioning that, under the climatic conditions of northern Ontario, there is very little drying

(*continued on page 16 A*)

Products for the paper industry

R. T. VANDERBILT CO.

230 Park Avenue, New York 17, N. Y.

(*continued from page 14 A*)

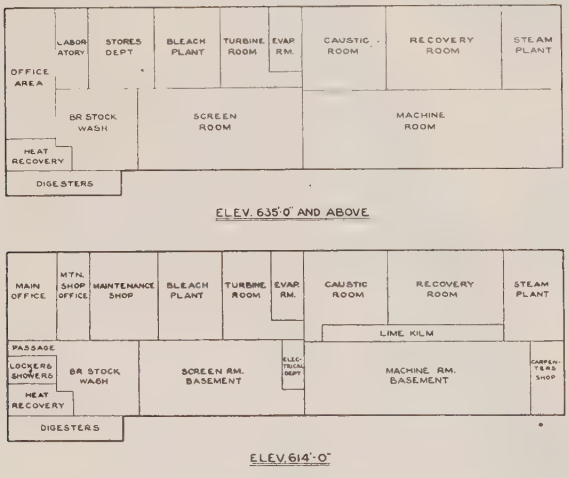
of wood in pile storage, except for a thin surface layer. The average wood moisture for May to October, 1948 with wood direct from the Lake was 44.2%, whereas the average test for November to March, 1949 on logs from storage was 43.4%.

Reclaiming during the winter season is done with two cranes (grapple and chains) and we may work from one pile or from two simultaneously. A long cable conveyor transports the logs to a wet barking or washing drum which is installed immediately ahead of the chipper. This drum is similar to the already mentioned dry units but there is a fresh water spray on the discharge end and recirculated water on the inlet. The temperature of this water is kept around 60°F. and we obtain satisfactory removal of sand and residual bark. The retention-time, however, is too short to thaw out frozen wood and this wet-drum is no substitute for a hot pond.

The logs are chipped with a Carthage 10-knife machine, having a 110-in. disk and running at 360 rpm. The capacity of this unit is large indeed and we put through normally 50 to 60 cords per hour, so that the weekly mill requirements can be satisfied with less than 72 hours of chipper operation.

The quality of the chips has not been entirely satisfactory and there is some objection to a rather high percentage of oversized pieces. To rectify this situation, chip screens and a rechipper are presently being installed.

Five large chip-bins, each holding about 240 cords, serve as storage and give a good reserve in the event of a major chipper breakdown. These bins are of the saw-tooth type, hardwood-lined, and each have five sections to discharge their contents on a set of



EXIST. MAIN MILL BUILDING LAYOUT
MARCH 1949

Fig. 3

five parallel conveyors, of which, each passes along the corresponding section of every bin. Chip-feeders control the flow. It is thus possible to withdraw chips at will from any section of any bin and to charge the digesters, if desired, with a relatively closely controlled wood mixture.

The five parallel conveyors transfer their loads to a wide rubber belt which passes over a Fairbanks-Morse weightometer, on its way to the digesters. This weightometer has given good service and plays an important role in our operations.

Mill Layout

Before we enter upon the description of the mill itself, I wish to mention that, perhaps for the first time, an attempt has been made to locate all the

Fig. 4. Digester operating floor

manufacturing units, such as steam and power plant, laboratory, offices, machine shop, and mill stores under one roof (Fig. 3).

It goes without saying that considerable planning was needed to arrive at a layout which is practical as well as convenient and economical. An appreciable degree of success was achieved and the numerous advantages of such an arrangement have been accepted with great satisfaction.

The Digester House

We have seven digesters of 3260 cu. ft. capacity which yield about 8½ tons of unbleached slush per cook. They are insulated and equipped for circulation and indirect heating. The seven blow lines join to a single pipe through a seven-port Sandberg valve. At the beginning, some difficulty was encountered with the operation and maintenance of this special valve but this, however, has been overcome (Fig. 4).

Instrumentation in the digester house is rather complete and operation is almost fully automatic. After considerable experimenting we have found it best to charge the digesters with a predetermined weight of bone-dry wood and add cooking liquor on the basis of a percentage which may be altered from time to time as conditions require. The liquor volume is dealt with on the same principle. The chip-weightometer is, of course, the equipment on which all this control rests, and digester filling is governed by its integrator control installed at the operating floor. There is, however, one phase of this technique that we are trying to improve. That is the quick and reliable determination of the chip-moisture. While we have achieved a certain degree of success we have not yet

(*continued on page 18 A*)

NO!!!... we don't mean that the various labor saving devices found in Downingtown machinery will give your mill hands "time to bum," but they will have more time to do other things, because of the many new labor saving features found only in Downingtown Fourdrinier, Cylinder, Wet and Wallboard Forming Machines and other individual units . . . Aside from the major labor saving features in each machine, you'll find many post-war improvements in design and construction. Many of these "thoughtful improvements" may not even show in our specifications or general drawings . . . But your men will see and appreciate them when they operate the machine . . . and, if they don't say it, they'll think to themselves "the man who designed this, or thought of that, had the papermaker in mind." These are the extras you get from Downingtown, that are "not extras in our quotations," but they, plus the major labor saving advantages, all add up to EASE OF OPERATION . . . Call us and, when you order, remember, "you'll get more," in *Thoughtful "Papermill-Wise" Engineering.*

DOWNINGTOWN MANUFACTURING COMPANY

DOWNINGTOWN, PA.

DESIGNERS AND BUILDERS OF PAPER MAKING MACHINERY SINCE 1880

(continued from page 16 A)

found exactly what we desire. White and black liquor flow to the digesters by gravity, the volume being controlled by automatic filling devices.

Every digester has its individual control panel in which are installed the pressure-time steam controller, the automatic-relief instrument and circulation discharge pressure-recorder. There is one temperature-bulb which is inserted in the digester proper and not in the circulation line.

This location was chosen for any eventual necessity of direct steaming without forced circulation and this in turn led us to select steam flow control by pressure rather than by temperature. Experience has shown that forced-circulation can be adjusted to give complete temperature uniformity throughout the digester at all times and a temperature steam-control would, under these conditions, perhaps be preferable. In direct cooks this uniformity does not exist and it is at such times that pressure steam flow control is better.

Our efforts have been so successful that the whole cooking operation could be put on a strict time-cycle, and while we still sample the pulp shortly before the blow we find it very rarely necessary to advance or delay blowing by a few minutes. As an illustration of the results obtained, I may mention that the weekly standard deviations from the desired permanganate number run generally in the neighborhood of 1 point.

The blow tank has a capacity of about 2½ cooks. It is equipped with a Foxboro dilution-controller and a level-indicator.

Blow heat is recovered in an American Heat Reclaiming system which is also fully automatic. The instruments consist of a temperature-controller for the blow-tank jet-discharge and the clean, hot water. The heat transfer takes place in two parallel spiral, heat-exchangers. The clean, hot-water-tank has a level indicator.

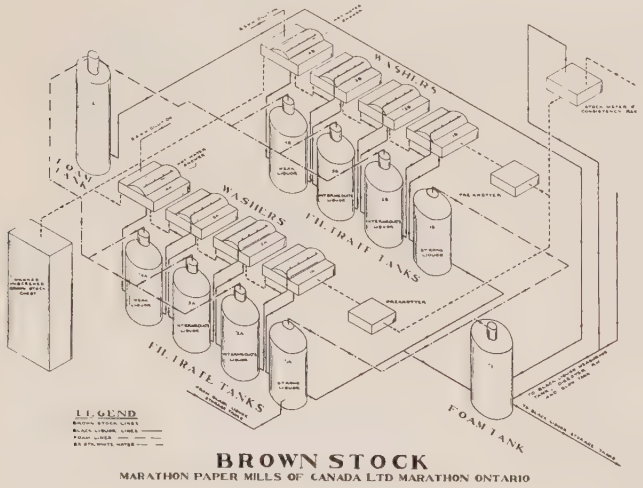


Fig. 5. Brown stock washing system

Pulp Washing

For the washing of the brown stock there are installed two rows of 8′ by 12′ Sherbrooke vacuum washers, with four effects in each row (Fig. 5).

This equipment is preceded by two Sherbrooke pre-knotters, fed from headboxes equipped with automatic level control, consistency regulators and Sherbrooke stock meters. Each of the eight washers has its own filtrate tank with level-recorders and the first stage has, in addition, a Baumé and temperature recorder. Fresh hot water flow to the fourth stage is automatically controlled and there are flow-indicators on each intermediate transfer pump.

Continuous brown-stock washing was first introduced in the southern United States and it has been generally believed that the interference by foam would in other sections of the country be less serious than in the South. There is not much information available in this respect from Canadian mills but we know already that Jack pine, in particular, can be as objectionable as the southern pines and sometimes perhaps more so. This nuisance has, however, been overcome through the installation of special foam-tanks and there may also be other ways to deal with it.

Rifflers and Screens

Following the manufacturing process, we come now to the rifflers and screens which have been installed both for brown and bleached stock. The rifflers consist of eight channels 8 feet wide and 72 feet long and are being operated at 0.35% stock consistency.

Smythe all-metal flat screens with chromium-plated bronze plates for brown stock and stainless-steel or Inconel plates for bleached stock give us a very clean pulp. Screening-capacity provided by 448 plates for the brown pulp and 280 plates after bleaching is ample indeed.

Pulp Bleaching

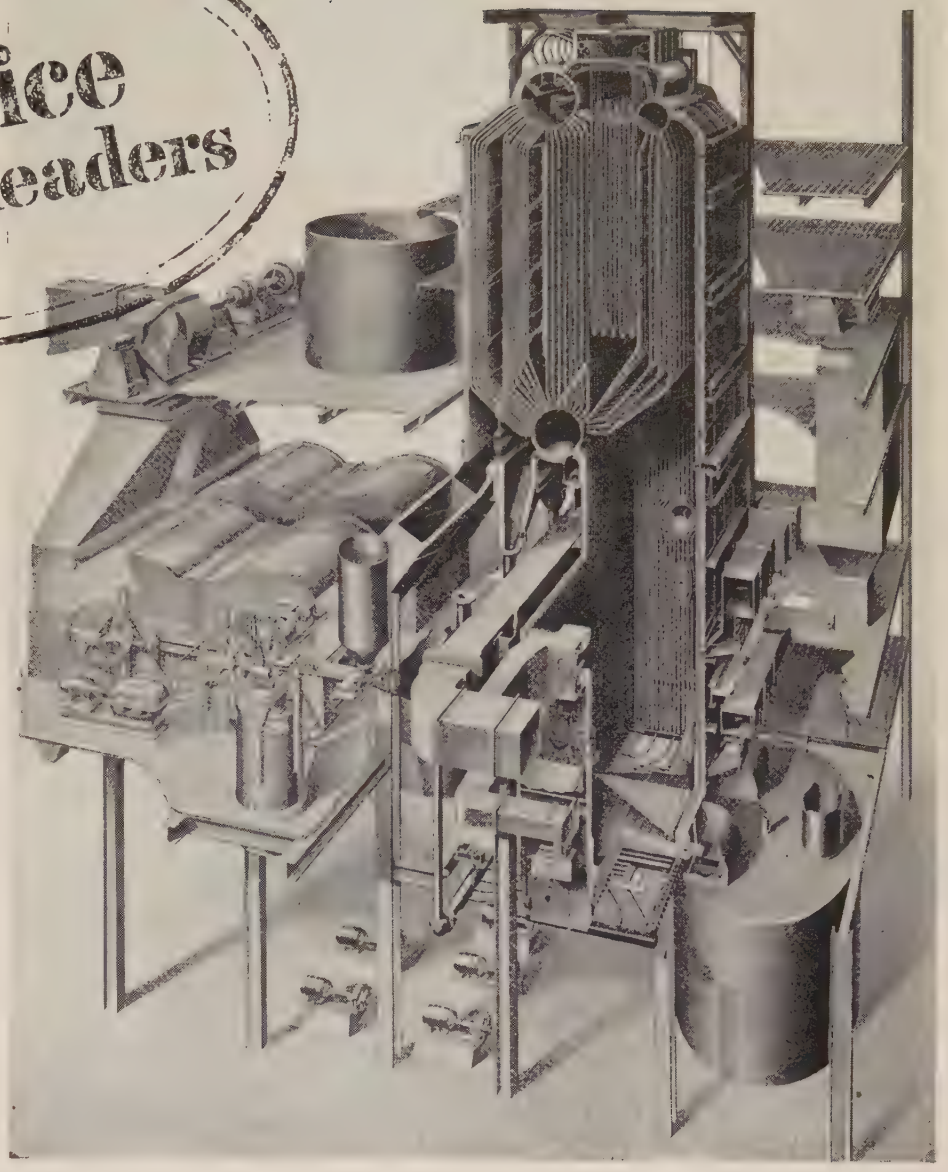
Bleaching of the pulp is one of our major operations so that we may be justified to treat it a little more in detail. The object, of course, is to obtain the brightness which the trade requires, without sacrificing too much of the pulp's strength and, at the same time, keep costs and pulp shrinkage at a minimum.

We all know that in pulp bleaching four principal operations must be performed which are, in natural sequence, the preparation of the noncarbohydrates for removal, their extraction, brightness development and brightness stabilization. The noncarbohydrates are made amenable to solution through the action of elemental chlorine. The extraction of these so-called "lignin chlorides" is done by means of caustic soda. Calcium or sodium hypochlorite produce the brightness, and mineral acids serve for its stabilization.

It is essential that these reactions be performed separately, so that a bleachery must have at least four independent stages. It is further necessary to eliminate thoroughly all solubilized-matter before the next step is taken and this is done by means of vacuum washers or high-density filters. Better results are obtained when the extraction-stage is repeated shortly before the final brightness is reached and some benefit results from dividing chlorination into two steps. Therefore, modern sulphate bleacheries may have five or as many as ten stages. We, at Marathon, have eight, and equipment and layout are such that we may follow most of the sequences that are in general use. Best results have so far been obtained with the se-

(continued on page 20 A)

Choice of the leaders



Pulp and paper companies that have purchased C-E Recovery Units for one or more mills.

•

Bloedel, Stewart & Welsh, Ltd.
Brompton Pulp & Paper Company, Ltd.
Brooks Scanlon Corporation
Brown Company
Brown Corporation
The Brown Paper Mill Company, Inc.
Brunswick Pulp & Paper Company
Central Paper Company, Inc.
The Champion Paper & Fibre Company
Chesapeake Corporation
Consolidated Paper Corp., Ltd.
Continental Can Company
Coosa River Newsprint Company
Crossett Paper Mills, Ltd.
Dryden Paper Company, Ltd.
Fraser Companies, Ltd.
Gaylord Container Corporation
Halifax Paper Company
Kalamazoo Vegetable Parchment Company
LongLac Pulp & Paper Company, Ltd.
Longview Fibre Company
Macon Kraft Corporation
Nanaimo Sulphate Pulp, Ltd.
National Container Corporation
National Container Corporation of Michigan
Nekoosa-Edwards Paper Company
North Carolina Pulp Company
Oxford Paper Company
St. Joe Paper Company
St. Mary's Kraft Corporation
St. Regis Paper Company
Sorg Pulp Company, Ltd.
Southern Advance Bag & Paper Company
Southern Paperboard Corporation
Southland Paper Mills, Inc.
Union Bag & Paper Corporation
S. D. Warren Company
Weyerhaeuser Timber Company

In all important pulp producing areas of the United States and Canada you will find C-E Recovery Units in the plants of leading pulp and paper manufacturers. A list of the companies that have purchased C-E Recovery Units appears at the left. In many cases these companies have placed repeat orders.

B-340

C-E

COMBUSTION ENGINEERING—SUPERHEATER, INC.

A Merger of Combustion Engineering Company, Inc. and The Superheater Company

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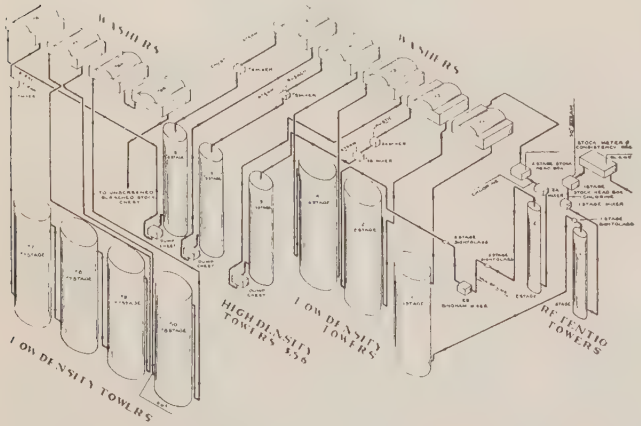
PRODUCTS FOR THE PAPER INDUSTRY INCLUDE RECOVERY UNITS, STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; ALSO PRESSURE VESSELS

(*continued from page 18 A*)

quence: chlorination, Hooker chlorination, alkali extraction, hypochlorite bleaching, alkali extraction, hypochlorite bleaching, and acid treatment. With three exceptions all these operations are carried out at low consistency; high density is used only for extraction and the first hypochlorite bleaching (Fig. 6).



BLEACH PLANT
MARATHON PAPER MILLS OF CANADA LTD MARATHON ONTARIO

Fig. 6

The plant is fully continuous and automatic; the retention vessels consist of concrete towers with bottom feed for low consistency and gravity-flow where high density prevails.

As indicated by the name of the first stage, elemental chlorine is the chemical agent used in this operation. Its industrial application has preceded scientific studies by some time but the main reactions are now known; they are predominantly substitution and, to a lesser extent, addition. About 55 to 60% of the applied chlorine is converted into hydrochloric acid and all equipment must therefore be chlorine- and acid-resistant. In this respect, we have had good service from rubber-covered steel and acid-proof tiling.

If, for some reason, a double chlorination is desired, the so-called "Hooker-process" has some advantages over the acid method. This "Hooker-process" was originally proposed by Rue and Sconce and provides for the injection of milk of lime about 10 minutes after the elemental chlorine has been mixed with the stock. This milk of lime combines with the remaining free chlorine to form calcium hypochlorite which acts immediately upon the fiber. The conversion of the free-chlorine into hypochlorite makes it possible to transfer, in this stage, more chlorine to the pulp than could be done under similar conditions in an acid medium, and sometimes a mill may wish to have such intensive chlorination. On the debit side, there is the cost of the lime and the waste of chlorine in the oxidation of the already solubilized-lignin compounds by the newly formed hypochlorite.

The caustic extraction which now follows takes place at high density. The reaction conditions depend entirely on the desired quality, the degree of chlorination and in general it may be said that it is our aim to remove the noncarbohydrates as completely as possible.

At this point the pulp is ready for brightness development which is achieved by simple hypochlorite bleaching. However, as already indicated, we do not attempt to reach the final brightness in one operation but do so by a second hypochlorite-reaction which takes place after the pulp has once more been subjected to an alkaline extraction. We stabilize the brightness by an SO_2 treatment and have achieved satisfactory results.

The washers and filters are all 8 by 12 units built by Sherbrooke; the final washing is done on a duplex machine, which allows a maximum recovery of the SO_2.

Upon entering the bleach plant the brown stock passes through a consistency-regulator and a stock-meter which we have found quite helpful in keeping the flow under definite control. The instrumentation is very complete. Besides the usual level-recorders for milk of lime, bleach liquor, concentrated and diluted caustic and so on, we have steam-flow controllers on every stage where heating is required. The addition of the gaseous chlorine, caustic for alkalinity-adjustment and of SO_2 is controlled by rotameters, whereas the caustic for the extraction-stages and the hypochlorite are again automatically metered. We have had and still have some difficulties with the latter equipment, consisting of disturbances created by lime-deposits. Level-recorders on basis of the bubble-pipe are installed on the three high-density towers, and their indications give the operator information as to the height of the stock in these vessels.

Much attention has been paid to the uniform mixing of chemicals and pulp. Improved Machinery Company chlorine mixers are used in the first two stages and Thorne double-shaft high-density mixers in all others.

Pulp Drying

The pulp coming from the bleachery is again riffled and screened and flows to two Kamyr wet-machines. These have a 136-inch working width and are equipped with a vacuum pump, hot water showers and three rolls, all of which have pneumatic loading facilities. The web leaving the mould has a dryness of about 29%; it then passes through two heavy presses with a set of predriers, in-between. The equipment works entirely without a felt as the sheet is strong enough to carry itself. Having reached a dryness of about 55% the web enters the Swedish Flakt driers. These are long chambers in which the pulp, resting on rods, travels back and forth several times. Drying is accomplished by hot air being blown across the sheet and there is no direct contact with metallic heating surfaces. Steam economy is very good as, with one pound of steam, we can evaporate a pound of water. We also give this kind of drying part of the credit for the very small drop in the pulp's brightness between the machine headbox and the finished sheet.

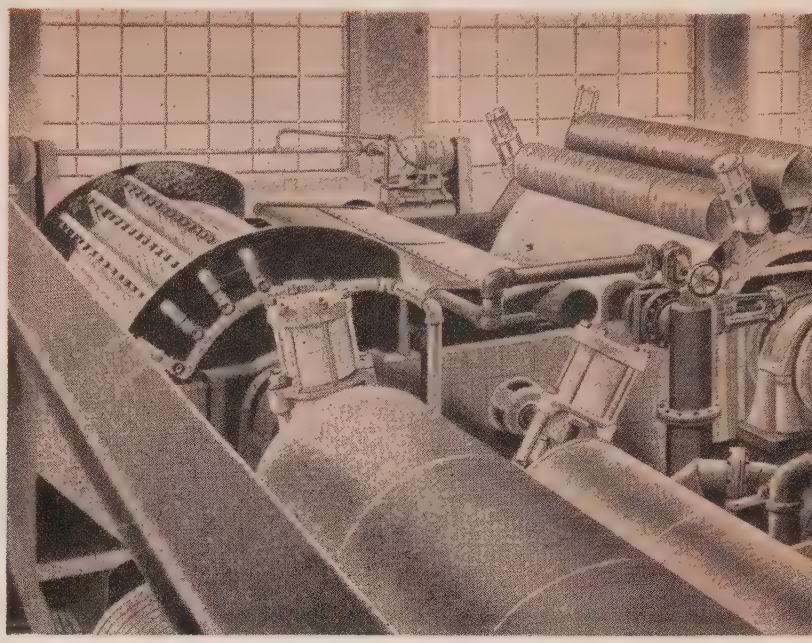
Automatic layboys build up the stacks of sheets which are needed to give 500-lb. bales. These, in turn, are pressed, wrapped and conveyed automatically to the shipping room (Fig. 7).

Instrumentation of the drying-machine room consists of an integrating steam-flowmeter, steam-pressure

(*continued on page 22 A*)

as you were in 1900

Paper bleaching was a slow
and uncertain process
at the turn of the century



as you are today

Bleaching with liquid chlorine in a
modern mill is fast, efficient, precise

. . . with pioneering aid from Niagara Alkali

An old industry with young and progressive ideas, the paper industry has made tremendous strides forward since 1900—in the speed and efficiency of its methods and the quality, variety and utility of its products.

Niagara's pioneer production in America of liquid chlorine and caustic soda helped to make such advances possible in the paper industry—and in the textile, soap, glass and other fields. For pioneer quality and service in electro-chemical products look to Niagara.

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60 East 42nd Street, New York 17, N. Y.

Liquid Chlorine • Caustic Potash • Carbonate of Potash • Paradichlorobenzene • Caustic Soda • NIALK TRICHLORethylene

(continued from page 20 A)

controllers, seal-box-level controllers and press-load recorders. There are also the electrical instruments, including a voltmeter which indicates the operating speed.

Fig 7. Pulp storage

Chemical Recovery

We may now leave the pulp which is baled and ready for shipment and return to a consideration of the black liquor in the storage tanks. It is known that sodium sulphide and perhaps also the mercaptans hydrolyze with development of sulphuretted hydrogen when their aqueous solution is heated and particularly escapes with the evaporator condensate and also with the recovery furnace gases and these losses have been estimated to amount to about 90 and 30 pounds of saltcake respectively, per ton of pulp. It is further known that these same sulphur compounds can fairly easily be oxidized to sulphur, sulphites, or sulphates and are then no longer susceptible to hydrolysis. These facts were reported three years ago by Tomlinson and Swartz in the Pulp and Paper Magazine of Canada and the Babcock and Wilcox Company have designed a black-liquor oxidation tower to accomplish this objective.

At Marathon we operate such a unit and have had very gratifying success. The oxidation takes place at the normal temperature of the black-liquor and the oxygen comes from air, blown into the tower by a fan. The main point is to create a large surface for the transfer of the oxygen from the air to the liquid phase without creating foam. This is not always easily accomplished. Oxidation efficiencies as high as 80% have been reached and the operators report a more uniform run of the vacuum-evaporators when they are supplied with stabilized black-liquor.

Our evaporator room contains six effects with two steam units and split feed of the liquor to Nos. 6 and 5 effects. The equipment was designed by Goslin-Birmingham Company and the instrumentation is very complete. It consists of a liquor flow controller to the split effect, a steam pressure controller, an eighteen-point dynalogue, an integrating steam-flowmeter, and a Baumé-controller for the evaporated liquor. This latter instrument acts on the temperature difference between the gas-and the liquid-phase of the thick liquor. It was installed quite recently but has already rendered most valuable service. There are also the level-recorders on thin- and thick-black-liquor storage. The instrumentation allows full automatic operation; this however, we have not actually tried out because of the late arrival of the Baumé-controller.

The thick black-liquor is further concentrated in Babcock and Wilcox cyclone scrubbers, of which we have one for each of the two recovery furnaces. These scrubbers are quite simple and have no moving parts. Ours are steel tanks about 20 feet in diameter and 45 feet high with a tangential furnace gas-inlet near the bottom and a gas-discharge at the top. The furnace gases enter these units at approximately 600°F. and transfer about 350°F. of their temperature to the thick black-liquor which is pumped into the scrubber through sprays at the throat of the gas-inlet. The liquor then runs into a sump from which it is picked up by circulating pumps and reinjected through additional sprays at the gas inlet and through wall wetting sprays around the upper circumference of the tank. About 5% of the circulated liquor at 60 or more per cent solids is continuously bled off to the salt cake mixing tanks and from there to the recovery furnaces.

Our two units are the conventional Babcock and Wilcox-Tomlinson type of the standard two-drum Stirling design. They each deliver 70,000 lb. per hour steam at 615-lb. pressure and 715° total temperature. The furnaces are completely water-cooled with a thin lining of chrome-refractory in the firing zone. For the purpose of cleaning, they have one retractable soot-blower at the entrance to the first convection pass and eight fixed-position rotating blowers further back in the boiler and economizer. In addition to two blowings per shift there is some hand-lancing required to keep the boilers free of salt cake accumulation. Salt cake reduction keeps in the middle 90's and the steam production near the 10,000-lb. level.

In selecting the instrumentation we again had in mind to provide as much as possible for automatic control; Bailey Meter Company equipment regulates the combustion and steam production, whereas Foxboro Company instruments are used on the dissolvers for level and specific-gravity control.

In our recovery system, besides the oxidation tower and the cyclone scrubber there is a third unit which aims to reclaim from the fumes the solid particles as well as gaseous sulphur compounds. For this purpose we wash the cyclone exit gases in a vertical run of breeching with water, which is introduced through counter-current sprays. The larger part of this washing liquid settles out of the gases in the base of the following cyclonic separating-tower which, in turn, causes the removal of the finer spray particles.

From the base of this tower, the liquid is pumped to a high-vacuum flash-tank in which it is cooled, through flashing, from about 160 to 120°F., the vapor passing to a barometric condenser, while the cooled liquid is pumped back into the gas washing-sprays. Being below the dewpoint of the primary cyclone exit gases, this cooled liquid causes considerable moisture

(continued on page 24 A)

Wanted:

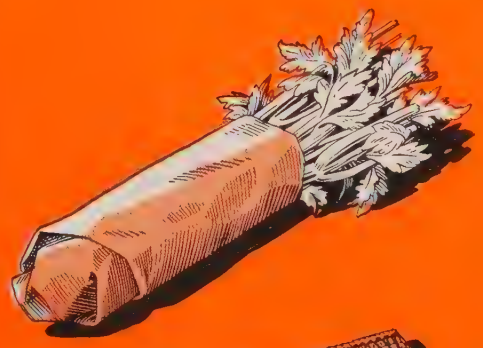
Fastness to water bleeding

Found:

Du Pont Dyes

Pontamine* Fast Yellow BBL Conc. 125%
Pontamine* Fast Orange MRL Conc. 125%
Pontamine* Fast Scarlet 4BS Conc. 150%
Pontamine* Brown D3GN Conc. 125%
Pontamine* Orange R Conc.
Du Pont Purpurine 4B Conc.
Pontamine* Fast Blue 4GL Conc. 150%
Pontamine* Fast Blue RRL Conc. 175%
Pontamine* Deep Blue BH Conc.
Pontamine* Black E Double

Selected Basic Dyes on Unbleached Pulp



Careful selection of these dyes, and at times the use of mordants such as Du Pont Mordant DP and BS will give you specialty papers with colors which will not run or stain other items.

Our Technical Staff is always glad to help you find the right dyes to meet your specific requirements. E. I. du Pont de Nemours & Co. (Inc.), Dyestuffs Division, Wilmington 98, Delaware.

*REG. U. S. PAT. OFF.

Du Pont Dyestuffs

DU PONT
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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

(continued from page 22 A)

condensation, thereby precipitating salt cake fumes.

As make-up we are using water and build up a concentration of about 20% solids. From that point on, a quantity sufficient to keep the whole system in equilibrium is bled off to the concentrated black-liquor system. Soda ash solution is admitted through a pH controller to assure the correct alkalinity and the absorption of sulphur oxides.

The exit gases from the secondary cyclone have a temperature of about 125°F. and virtually all useful heat has been extracted from them.

Causticizing

The alkali room uses the continuous Dorr causticizing process. Green-liquor is pumped from the dissolvers into a storage tank from which it flows by gravity through a controller to the green-liquor clarifier. This is a Dorr balanced-type tray thickener with 4 compartments and measures 32 feet in diameter and 22 feet in height. The lime needed for causticizing is preslaked in a Kilby rotary and the process is finished in a bowl slaker combined with a classifier. Part of the clarified green-liquor is directed into the rotary and part to the bowl unit, in either case being heated by steam injection to about 210°F.

The conversion of the sodium carbonate into the hydroxide requires about 75 minutes and takes place in three causticizers which are installed in series. These units are 10 feet high and have a diameter of 12 feet. The white-liquor clarifier and the lime-mud washer are of the same size as the green-liquor clarifier, whereas the dregs-washer has a diameter of only 22 feet. After about two years of operation the original piping showed signs of severe corrosion, particularly in the white-liquor system. A systematic replacement with 5% nickel material has so far been satisfactory.

The washed lime mud is concentrated on an Oliver filter and enters the kiln at a dryness of about 54%. This kiln is an 8- by 140-feet Allis-Chalmers unit with a 42-foot chain section and full automatic control. The availability of the reburned lime generally averages 90%.

Besides the instruments already mentioned, the caustic-room panel contains the level-recorder for weak wash- and green-liquor storage and an integrating steam flowmeter. On the kiln-panel we have an oil-flow meter, burning-zone temperature-controller and exit-gas temperature-indicator, as well as a hood-draft-controller. There is also a lime-mud storage level-indicator. On this tank, as well as on milk of lime storage, in the dissolvers and other similar vessels we have often been inconvenienced by plugging of the bubble pipes. This nuisance was first reduced by the installation of large diameter pipes ($^1/_2$ to 1 inch) but has been entirely eliminated through the use of the new Taylor unit (229-Type, transmitting element).

Steam plant

The steam needed in addition to that from the recovery boilers is supplied by two Combustion Engineering Company pulverized-coal boilers of 115,000 lb. per hr. capacity each. They are of the 2-drum integral-furnace-type with suspended superheaters. The furnace has a dry bottom and the ash is collected in a hopper from which it is periodically removed by a vacuum system. Each boiler has a forced draft fan of 40,000 cu. ft. per min. (7.1 inches Static Pressure) and an induced draft fan of 70,000 cu. ft. (10 inches pressure). The instrumentation is all Bailey Meter Company equipment.

The relatively high steam pressure and temperature require well-treated feed-water and although Lake Superior supplies the best we can desire, from a manufacturing point of view, a rather intricate system of feed-water treatment is being used. It proceeds in five steps which are: softening by carbonaceous zeolites, acidification, carbon dioxide removal, deoxygenation and internal phosphate treatment. The results of this purification have been extraordinarily gratifying in as much as every boiler inspection found the units in excellent condition. Also the steam quality has always been perfect, with an average conductivity of only 3 micromhos. The latter fact is important for the three turbines which supply the electric power for the mill and town.

The largest of these is a 7500-kw. double-extraction condensing unit built by Westinghouse. The other two are General Electric machines, each rated at 4000 kw. One of them has automatic extraction at 135-lb. and adjustable back pressure to 35-lb. The other has an automatic 35-lb. extraction and a Foster Wheeler condenser. Current is generated at 6900 volts.

Mill Control

In order to be successful, mill operation must, at all times, have reliable information with regard to the performance of the various departments, also on quality and efficiency. Management needs regular manufacturing reports and, from time to time, data on specific issues as a guide for their decisions. The technical department has to furnish all this information and has been so organized that these services may be rendered at minimum cost. It is composed of three sections, namely chemical mill control, instrumentation and statistics (Fig. 8).

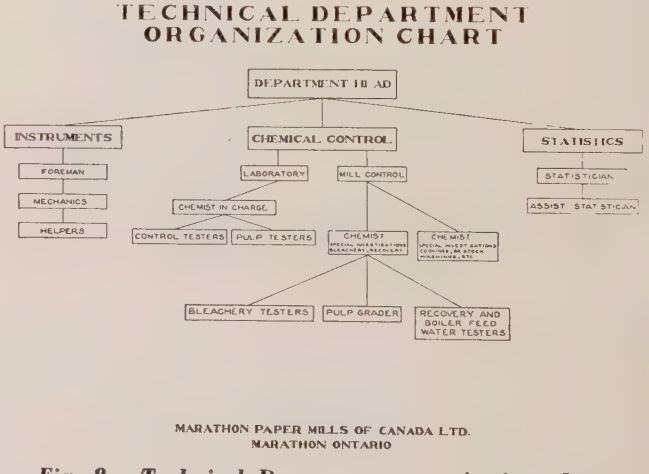

Fig. 8. Technical Department organization chart

The chemical section is not only charged with the customary routine control tests but also with the very numerous special analyses which crop up during the initial operating stage. Our location in the Canadian

(continued on page 26 A)

Paper Product Pointers
FROM CYANAMID

Re: Wider Markets for Paper...

ACCOBRITE

Newest ...Brightest of the Rosin Sizes

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IN LIQUID FORM

The ACCOBRITE** Rosin Sizes are unsurpassed for imparting high brightness value to sized papers – brightness that is retained in the paper even after aging.

ACCOBRITE Rosin Sizes are characterized by their low foaming properties. This may be reflected both as a definite savings in cost of foam killers and as an improved sheet formation – fewer foam spot complaints – fewer machine breaks.

ACCOBRITE Rosin Sizes are available in various solids concentrations and a wide range of free rosin contents.

ACCOBRITE Rosin Sizes are noted for their absolute purity and high quality. This new *improved* rosin size, with its outstanding machine performance, will please you with its excellent waterproofing, ink resistance, and general sizing results.

Consult your Cyanamid representative for full information about new ACCOBRITE Rosin Sizes.

ALWAX** Sizes • WAXINE* Sizes • Rosin Size • PAREZ* Resins
Synthetic Resins • Casein • Alum • Sulfonated Oils • Fillers
Defoamers • Soda Ash • Caustic Soda • Salt Cake • Acids • Clays
AEROSOL* Wetting Agents • CAL MICRO** (Calcium Carbonate)
AZITE** Liquifier 900 and other Paper Chemicals.

*(R) **Trade-Mark

Sales Offices: Boston, Mass.; Philadelphia, Pa.; Pittsburgh, Pa.; Baltimore, Md.; Charlotte, N. C.; Cleveland, Ohio; Cincinnati, Ohio; Chicago, Ill.; Detroit, Mich.; Kalamazoo, Mich.; St. Louis, Mo.; Los Angeles, Calif.; San Francisco, Calif.; Seattle, Wash. In Canada: Dillons Chemical Co., Ltd., Montreal and Toronto.

AMERICAN Cyanamid COMPANY

INDUSTRIAL CHEMICALS DIVISION

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

(continued from page 24 A)

bush, many hundred miles from the nearest city, does not make the job any easier. These distances make it impossible to get any help or information in a hurry from outside and one must be rather self-sufficient and solve most of the problems on the spot. We have found it advantageous to divide the work of this section into three branches, each headed by a chemical engineer or chemist. It was further agreed that all tests which could be made right in the various departments should be done there and that, in the laboratory, only such analyses would be dealt with that require lengthier procedures, delicate equipment or extra skill. Two of the three professional men are in charge of all control in the mill, special investigations and experimental runs, one looking after the unbleached pulp and the other after the bleachery and the finishing operations. The third man is in charge of the laboratory itself. We have a daily conference to discuss the problems of the whole department, at which time, the instrument foreman and the statistician sit in. The three chemists are sufficiently familiar with the others' duties so that they can take over at any time; thus we provide a seven day coverage within the frame of a 40 hour week (Fig. 9).

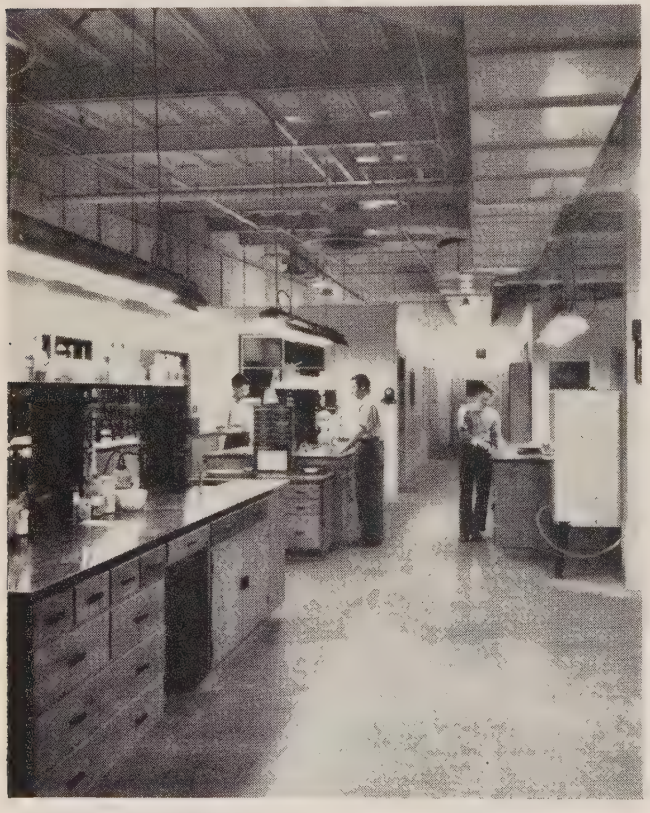

Fig. 9. Main laboratory

The instrument section is charged with the maintenance and repairs of all indicating, recording, and controlling instruments, except the genuine electrical meters and indicators, but including scales and consistency regulators. The mechanics, or rather their helpers, also change the charts so that the operators do not need to touch any instrument except for setting the control pointers. Every unit, primary, secondary, and the control valves, has its index chart on which the adjustments, repairs, calibration etc. are noted. We also have a schedule for systematic checks and overhauls.

The statistical section receives the departmental operational reports and instrument charts every morning after they have passed through the office of the superintendent and his assistants. They then average

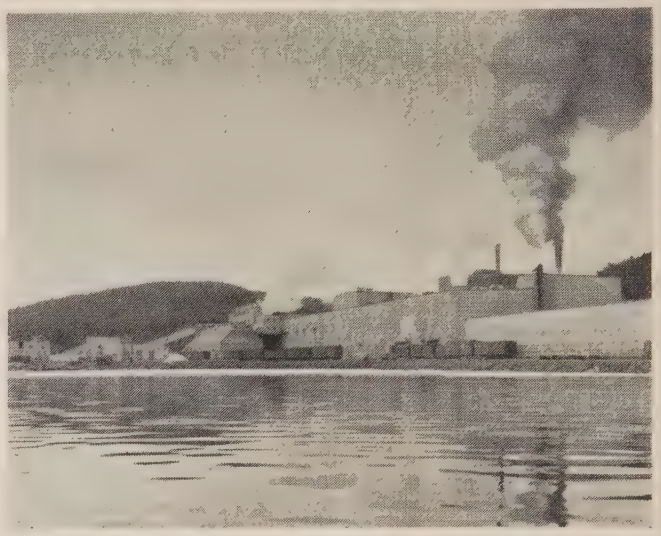

Fig. 10. View of plant from Lake Superior

and record the important data, some of which is used for control charts or other graphical representations. On the basis of these we issue daily, weekly, and monthly operational reports which are much appreciated by their recipients.

It may be needless to say that when our department was organized in 1946 there were very few experienced men available. Most of the help had to be trained by us in laboratory technique, the use of slide rules, adding and calculating machines and other basic functions. In the chemical section we followed the practice of having every helper pass from the easier, chiefly mechanical jobs, to more complicated duties and while at times of increased labor turnover this has put the supervisors under heavy strain, we feel that the effort was worth while as we now have a very strong and versatile organization (Fig. 10).

The Town Site

Constructing a pulp mill in Canada often means more than erecting the necessary buildings and machines and putting together an organization; in many instances there is no labor supply nor accommodation for employees and an entirely new settlement must be created. Those who have not seen these communities, of which there are quite a few, cannot appreciate the magnitude of the problem and the expenses involved and he who has not resided in one of them for some years seldom realizes to what extent the ultimate success of the plant depends on its adjunct, the town; because, despite all concepts to the contrary, life in the Canadian bush is neither a continuous picnic nor an uninterrupted succession of fishing and hunting trips (Fig. 11).

With the Marathon Corporation, the welfare of its

(continued on page 28 A)

These "PUMPING BONUSES" are YOURS when you specify "Buffalo"

Pay to the order of YOU
$$$ HORSEPOWER
SAVINGS

Pay to the order of YOU
$$$ LOWER
MAINTENANCE BILLS

Pay to the order of YOU
$$$ COSTLY TIMEOUTS
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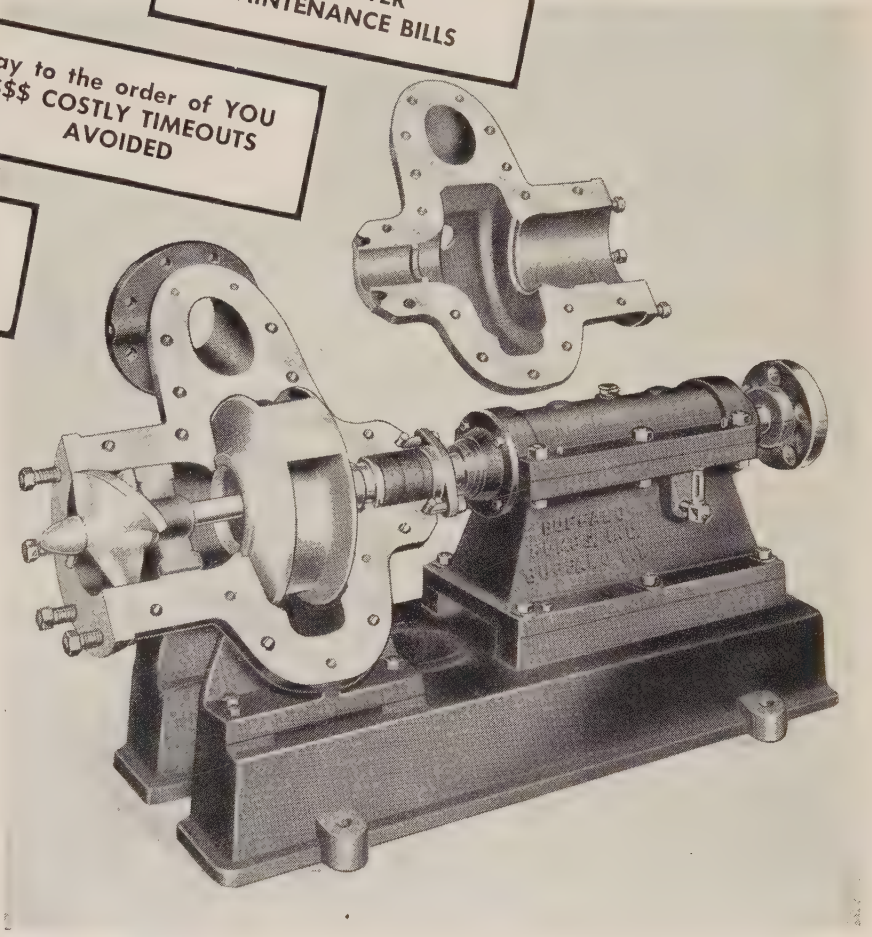
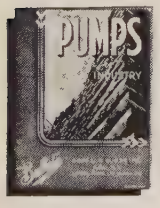


You get these "bonuses," first of all, through "Buffalo" high-efficiency impeller and casing design—high efficiencies which do not depend on close-running tolerances (which could cause extra wear, "wedging," and decrease in efficiency).

You get a big "bonus" in the over-all rugged construction of "Buffalo" Pumps. The special Non-Clogging "Buffalo" Impellers save many a maintenance dollar. Extra-heavy shafts, bearings and pump stands are built to take years of shock and punishment.

And best of all, you get a "bonus" in selection—the pump DESIGNED for your operation. The "Buffalo" line includes pumps for high heads, lumpy liquids, corrosive stocks, a wide range of chemicals—any condition you can name. All were designed in coordination with paper men, and have proven themselves in all kinds of installations.

Much appreciated by maintenance men, "Buffalo" Diagonally Split-Shell Stock Pumps have easily removable shells for quick inspection of all parts without touching discharge piping. Bearing also has removable upper casing.



WRITE for Bulletin 953-F—pick the durable "Buffalo" Pump designed for *your* stock, *your* consistency, *your* conditions!

BUFFALO PUMPS INC.

528 BROADWAY BUFFALO, NEW YORK

Canada Pumps Ltd., Kitchener, Ont.

A BETTER CENTRIFUGAL PUMP FOR EVERY LIQUID

(*continued from page 26 A*)

employees during and after work has always been a primary consideration. While it might have been enough, for a while, just to house the crew and their families, it was believed that contented employees are the best type of labor and it was therefore decided that the completed town should be a model industrial community which would attract and hold the best class of people.

Fig. 11. Coal unloading on dock

Following this program, an attractive modern town has been established which holds it own in comparison with the best in Canada. Four years ago, the spot on the north shore where we now find Marathon consisted only of sand, rocks, trees, and a few isolated shacks. Some of you people may have traveled in this part of Ontario and may have been amazed by its wildness and grandeur. It is particularly so in this section where, seventy years ago, history was being made when the Canadian Pacific Railway pushed their line to the Lake-head. At one time Van Horne, who was construction boss, swung 12,000 men and 5000 horses into the desolate waste which then was considered the American Siberia. The right of way through granite hills and over muskeg was an engineering nightmare. Most dreaded of all was the muskeg crust over underground bays, one patch of which swallowed three locomotives and seven levels of roadbed before it was conquered. Thirty thousand cars were required to carry the gravel to fill in a single trestle. The colossal quantities of rock to be blasted necessitated the building of several dynamite factories on the spot. The cost was exorbitant. At Jackfish Bay, three miles of granite had to be cut for 900 yards of forward travel and these three miles cost the C.P.R. $1,200,000 or almost $20 per inch. Today this district is rapidly developing into one of Ontario's most promising sections and Marathon plays no small part in this respect (Fig. 16).

Some of the controlling considerations in planning a town are: geological structure and topographical conformation; water supply and sewage disposal; exposure to sun and wind and climatic conditions; and natural beauty and proximity to plant.

The proximity of the town to the plant was a field for serious thought. The general experience in isolated districts has been that the employees who have the option do not desire to live too close to their place of work. As they are in contact with the same people all the time, they do not wish the plant to be another constant reminder of their confinement, and nowadays, automobile, bus, and other means of transportation facilitate their living some distance away. The specific problem of housing centered in providing at reasonable rentals, comfortable units for people of different stations in life, scarcity of certain materials and high construction costs.

Unfortunately nature seems to resent clearing a space in the forest for a townsite as experience elsewhere has indicated that, when adjoining trees are removed, those which one would have desired to preserve gradually succumb. Therefore, new trees and shrubs will have to be planted and lawns prepared. Thus, a basis will be established for loyalty and pride in the town and the inhabitants made to think of it as their "home." Our town was planned along these lines and gives to its residents already all the essential services and many of those facilities which make life pleasant.

Next to housing, education, medical attention, and religion are doubtlessly the most important requisites for a contented population. Realizing this, the Company provides absolutely free education for the children of all residents and has built a model eight room school comprising all grades up to the twelfth. The supervision is left to the advisory school board appointed by the Company. The attendance now stands at 206 and two additional class rooms will be built this summer.

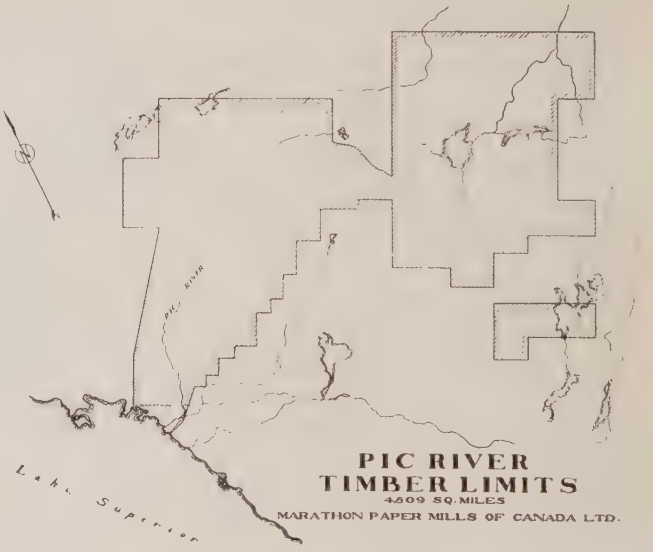


Fig. 16

A hospital is a "must" for any isolated industrial community, and our Wilson Memorial Hospital is second to none in layout, equipment, and capability of its staff and medical officers. The services it has already rendered cannot be overestimated (Fig. 12).

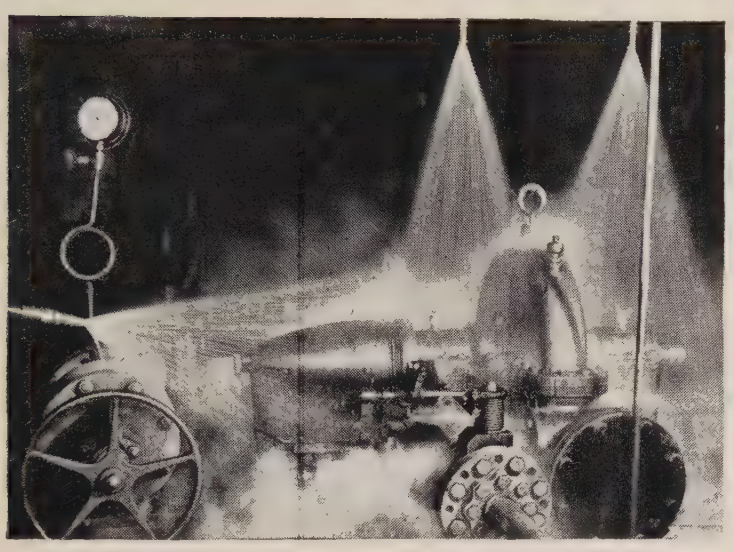
Two beautiful churches, in their location side by side at the top of a hill, symbolize better than anything else the fine and cooperative spirit which exists between the citizens of Catholic and Protestant faiths. With regard to the latter, ours is the first successful

(*continued on page 30 A*)

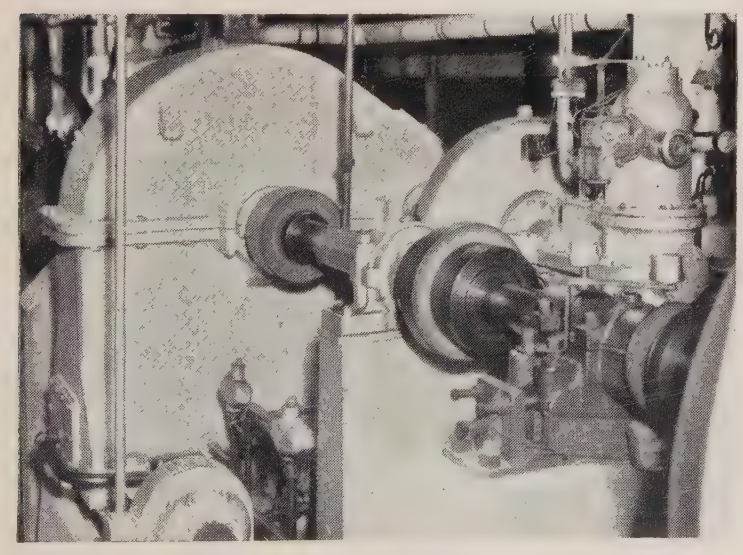
YOU CAN BE **SURE**.. IF IT'S

Westinghouse

No time for "TIME OUT"



Pouring-water tests that run for hours and hours—with turbines operating and standing still—prove the effectiveness of the Type E bearing seals against contamination of lubricating oil by water.



This turbine, designed for the paper industry, is direct-connected to the line shaft of a paper machine. The special variable speed governor provides precision control over a wide operating speed range.

Mechanical drive turbines in the paper industry must be dependable. They may be used either for long, continuous service, or for instant stand-by operation.

Westinghouse Type E turbines can be counted on for just such dependability. Their carefully studied design protects them against corrosion, moisture or dirt normally encountered in paper mill service. In addition, they operate safely with the varying steam pressures sometimes encountered.

Type E turbines, ranging in size from 5 to 1500 hp, can be used in many applications in and around paper and pulp mills. Weather-proof and dirt-proof, they are at home outdoors or indoors. Typical applications are hydro-pulpers, paper machines, beaters, pumps, fans and compressors.

Type E is the latest addition to the famous family of Westinghouse general-purpose turbines.

If your paper processes require modern drives that will take no time for "time out", call your nearest Westinghouse District Office. Paper Industry Application Engineers will be glad to recommend the right drive — whether mechanical or electrical — for any step in the making, finishing and converting of paper products. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-94792-A

Westinghouse

(continued from page 28 A)

experiment in Canada to unite all the different Protestant groups in one congregation.

When a town is first constructed it is difficult to interest business men, who have capital enough for the required stocks and supplies, to establish themselves in this new community at their sole risk. Being situated in a district with geological and climatic conditions unfavorable for the production of essential dairy and farm products, the obligation of their supply and all others falls upon the Company. This fact explains why, for the first few years, these new towns are of the "one store" category (Fig. 13).

Fig. 12. Wilson Memorial Hospital

During the early stages of the town's existence, while its residents, who came from all parts of the Dominion and from other countries, are being molded into a balanced and vigorous community, the Company has to show the way and assure that the right course is being held. The highest form of development, however, can never be a Company-sponsored scheme of general application. It must be planned and tailored to meet the various needs of the people and ultimately conform to their will. In spite of the fact that our district was incorporated only two years ago it has already developed a community spirit and a friendly atmosphere of which we are proud and which we think is an intelligent endorsement of the principles followed. The citizens have formed clubs and organizations for almost every conceivable physical and spiritual need; through united effort they have built an outdoor swimming pool, curling rink, tennis courts, and ski run. We have Girl Guides and Boy Scouts.

Fig. 13. Fire Hall and Police Station

Fig. 14. Everest Hotel

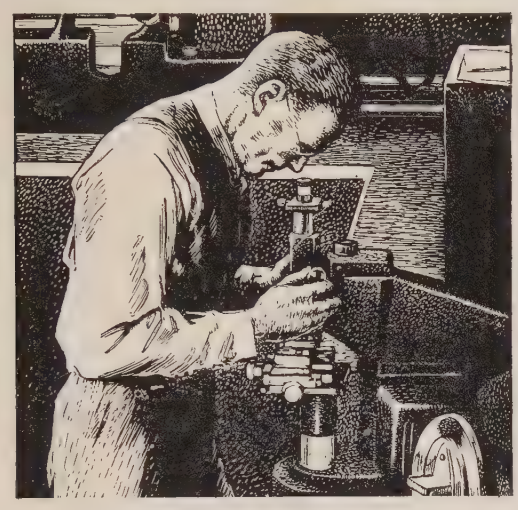
There are other amusements of various sorts, one of which is the 500 seat movie theatre (Fig. 14).

The Company felt that the town should not be without a tongue; thus a weekly newspaper was launched which is delivered free to every house. It is a smart little paper of high standard and covers all events of local importance. Recently its sixtieth number came out and announced, amongst other happenings, that the 180th baby had been born in Marathon. Our statistical group informs us that such an annual increment of over 4% puts the population on a perpetual basis so that our Woods Division need not worry about who will process the timber of which they feel sure they have a perpetual supply (Fig. 15).

Fig. 15. Town center with theater, bank, hospital, school, and recreation hall

Presented at the meeting of TAPPI Lake States Section, Appleton, Wis., April 12, 1949.

3 GOOD REASONS WHY APPLETON WIRES ARE GOOD WIRES



Appleton Research

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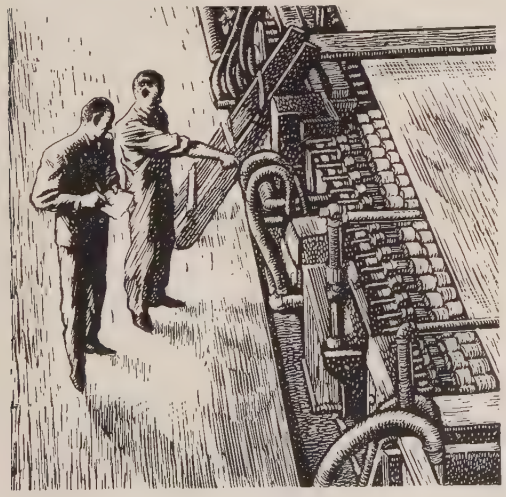

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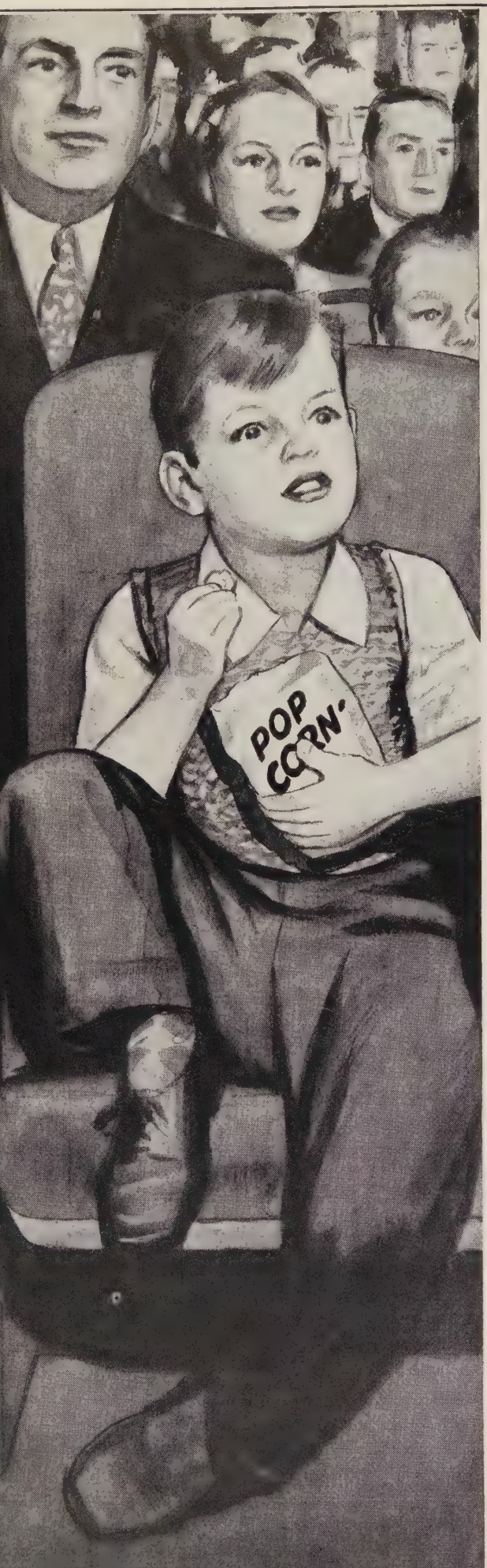

NOISELESS PAPER POP CORN BAGS

(NEWS ITEM: *It is estimated that 90 million noiseless paper pop corn bags are used annually in New York City movie houses.*)

The movie people have discovered a way to please pop corn enthusiasts without disturbing theatre-goers. They use a new type of noiseless paper bag made of facial-like tissue. To foil noise-loving small fry, holes are punctured along the sides of bags during manufacture, eliminating the usual farewell burst of noise from empty bags. Manufacturers' names on request.

Disposable paper shipping pallets . . . waterproof paper shower slippers . . . flower pots made of paper . . . new uses for paper calling for new standards of lightness and toughness, new standards of quality in performance.

To meet these new responsibilities and new opportunities developed by the Pulp and Paper Industry, the Puseyjones Organization is now devoting itself completely to the design and construction of Paper-Making Machinery built to new high standards of speed and efficiency, and to the modernization of existing machines.

Additional capacity in Metals Fabrication is now available through conversion of facilities formerly devoted to the building of ships.

Puseyjones Engineers will welcome the opportunity to work with you in solving production problems.

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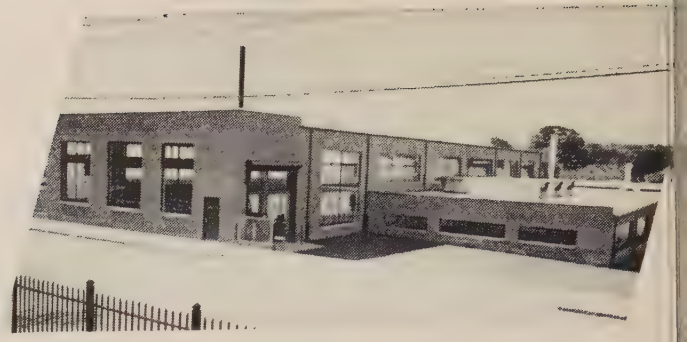
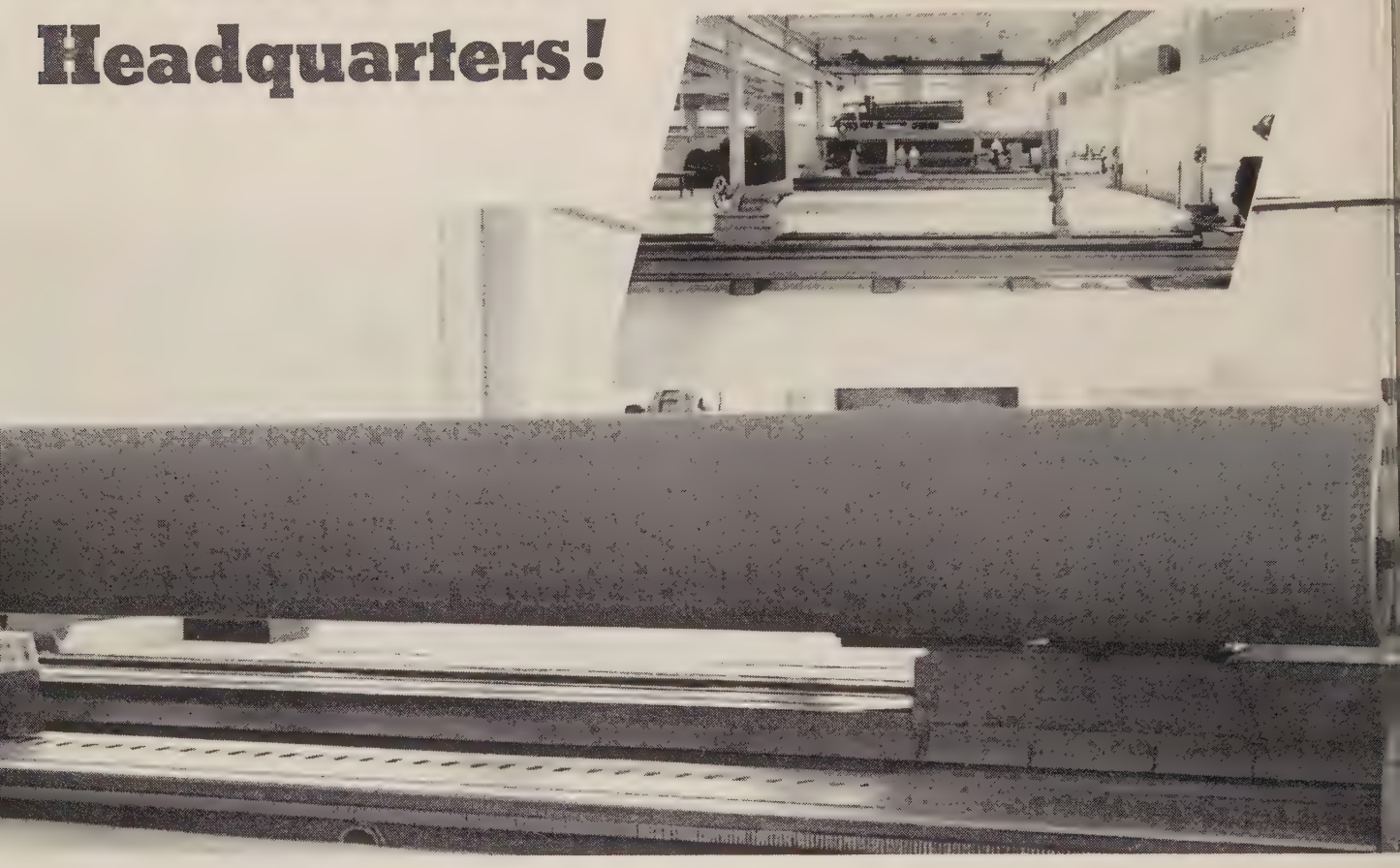
There's a NEW LOOK at Rubber Roll Headquarters!



Above: Exterior of new Ward plant addition at Stowe-Woodward, Inc.

Below: A section of the interior looking toward elevated loading platform. Farrel Grinder in rear, lathes in foreground, vulcanizers at left.



New 42′ 3″ Farrel Rubber Roll Grinder, LARGEST AND LONGEST OF ITS TYPE IN THE U.S.A.

You're looking at Stowe-Woodward's new Ward plant addition . . . built and equipped for the single purpose of making the finest rubber covered rolls to your most exacting requirements. Here you will find the tools, the will, and the skill that have justly made Stowe-Woodward the place to turn when quality is basic, service is urgent, or a new rubber roll development must be pioneered.

Typical of the new equipment is the Farrel Roll Grinder which will grind and crown rubber rolls 60″ diameter by over 300″ width of face with tolerances held to .0005″. This grinder and other new facilities symbolize our determination to serve you even better in the days ahead.

STOWE-WOODWARD, INC.

Craftsmen in rubber

NEWTON UPPER FALLS 64, MASSACHUSETTS

Careful Buyers of Caustic Soda and Chlorine

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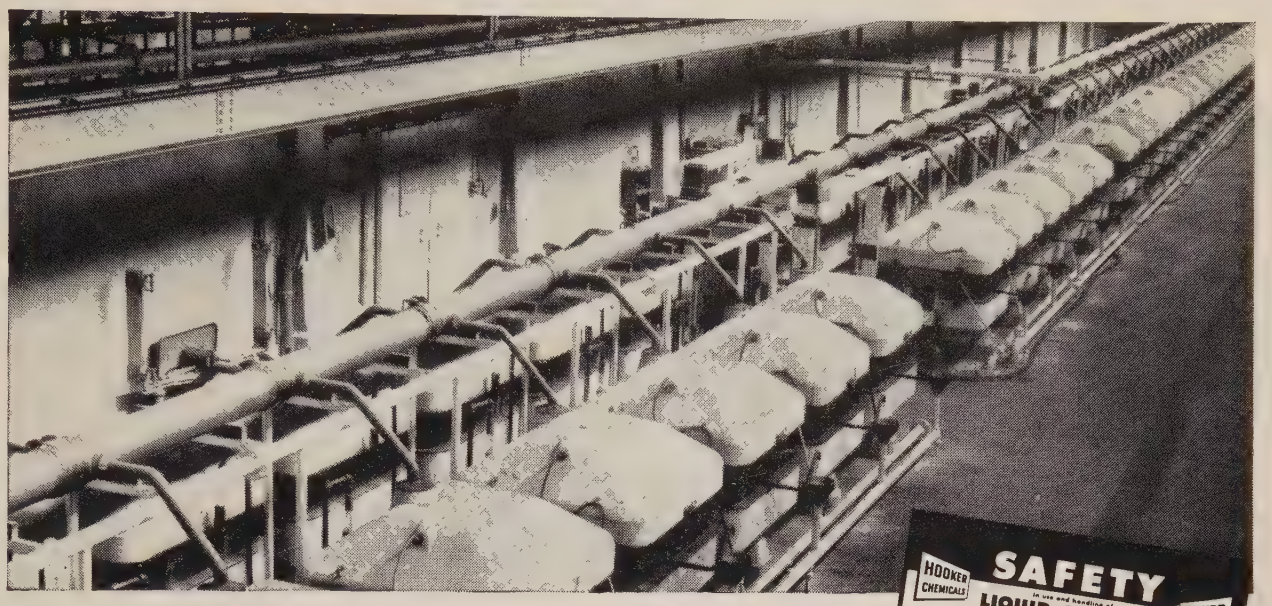

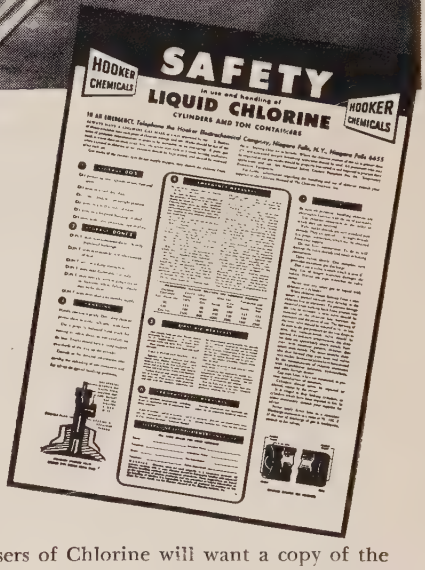

In the Hooker Electrochemical Company you have a dependable source for caustic soda and chlorine of high quality and constant uniformity. This is testified by the increasing number of users who year after year continue to secure their requirements from Hooker.

They have learned through experience that they can rely on these products of the famous Hooker "S" Cell. Produced under watchful control, each shipment is of the same uniform high quality. Through careful inspection and care of containers it reaches you in the same condition it leaves our plants.

Hooker Caustic Soda is available in solid, flake, or liquid form. Liquid is available in 50%, 73% and special grade solutions.

Hooker Liquid Chlorine, of standard market quality, is shipped in cylinders, multi-unit cars and tank cars.

For uniform processing from uniform Liquid Chlorine and Caustic Soda, specify Hooker.

Users of Chlorine will want a copy of the Hooker Wall Chart, "Recommendations for Safety in the Use and Handling of Chlorine in Cylinders and Ton Containers". Printed in large readable type on linen backed paper, it is ideal for mounting wherever you use or store chlorine.

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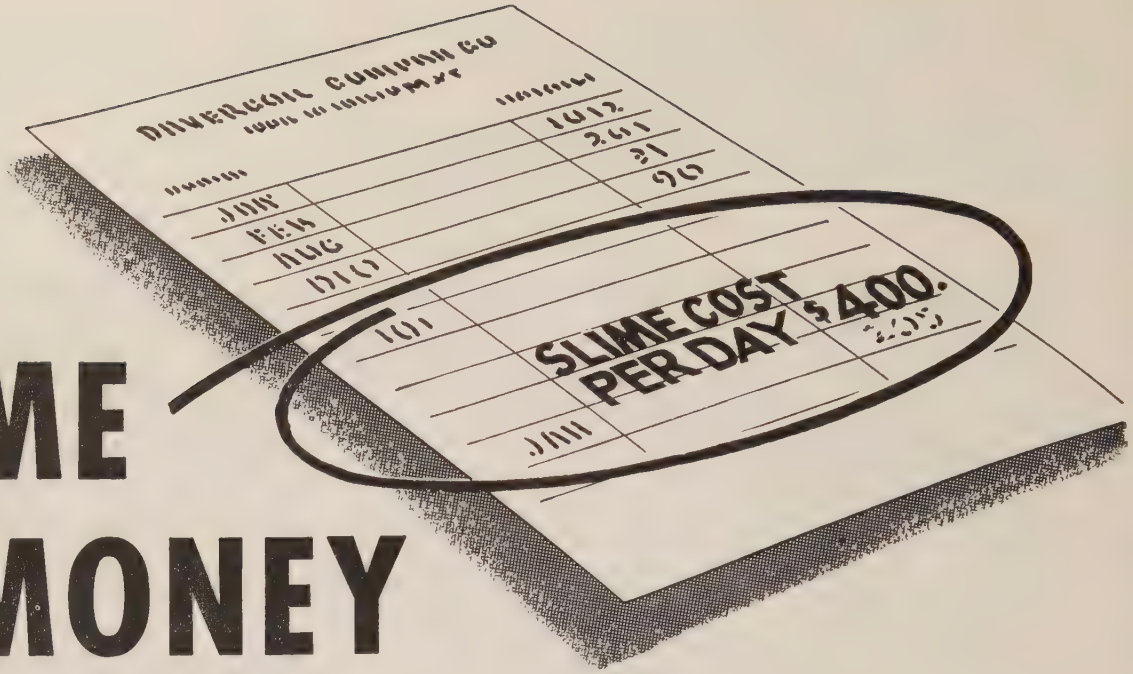
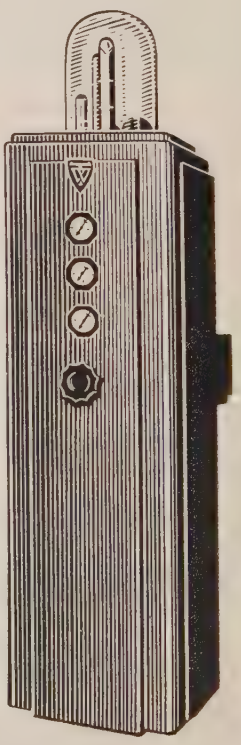


SLIME IS MONEY

Although you may never see a bill, studies show that slime costs the average paper mill $400 or more a day and is responsible for such costly troubles as wet end breaks, pin holes, slime spots, poor sheet formation, etc.

Break-Point Chlorination, engineered to your particular needs, has proven its slime fighting ability in hundreds of installations. This process, applied by dependable W&T Chlorinators, to your fresh water supply, often in conjunction with chloramines or other corrective chemicals to your stock or white water, gets results because it destroys the very cause of the trouble — slime forming bacteria. Moreover, members of W&T's nation-wide service organization with over 35 years' experience at their fingertips, carefully engineer each installation, to insure that you will receive maximum protection against slime at the lowest possible cost.

Your nearest W&T Representative will be glad to give you full details on how Break-Point Chlorination can cut your slime costs. Call him today.



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is a grade of quality Woodpulp,
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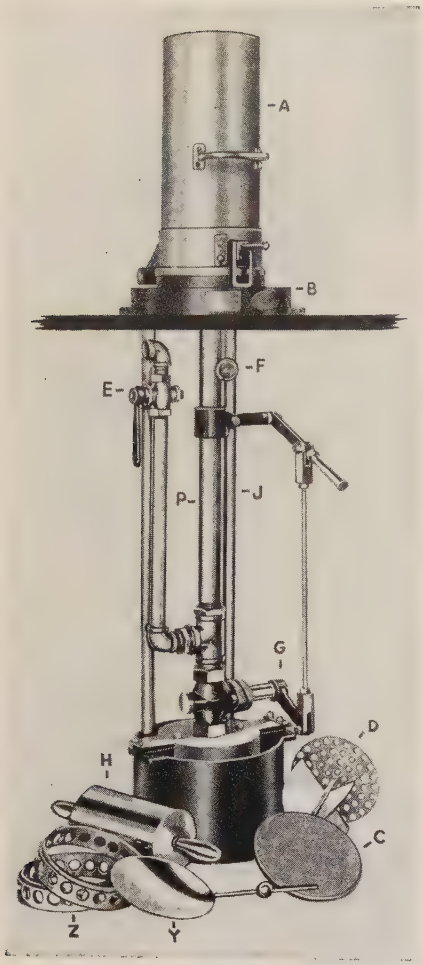
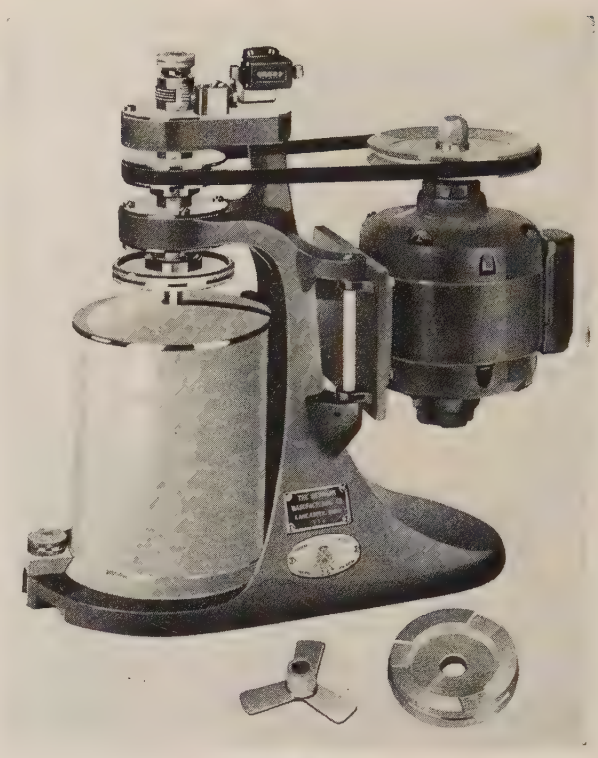
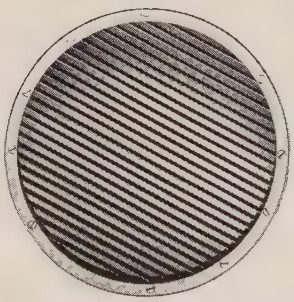


*SHEET MACHINE—DRYER RINGS—DISCS



*DISINTEGRATOR



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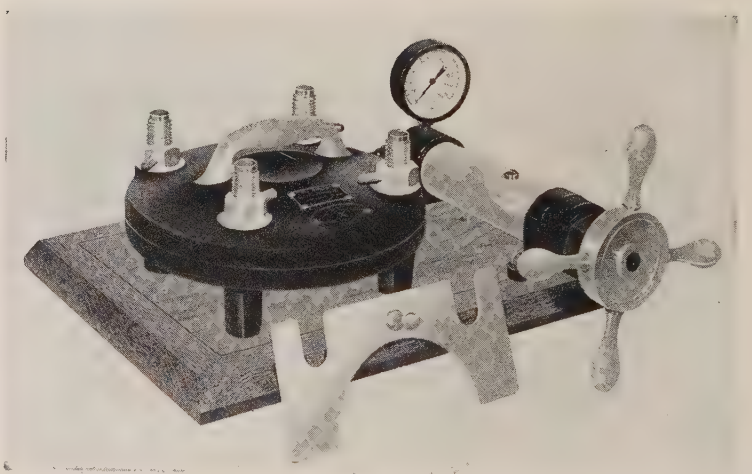
TECHNICAL ASSOCIATION PAPERS, SERIES 29-S



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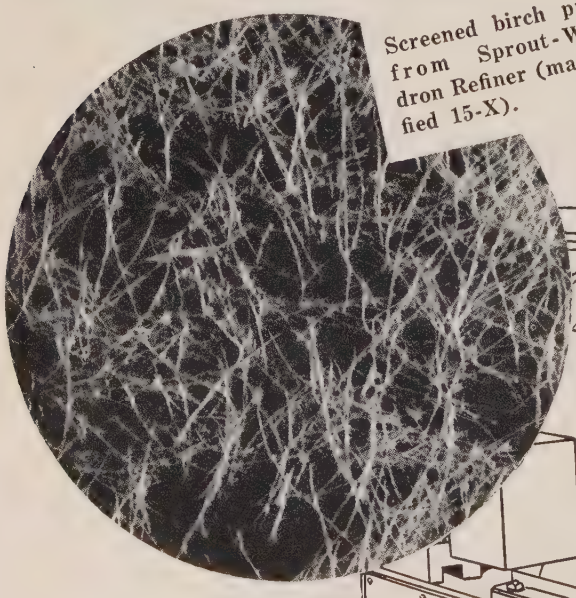

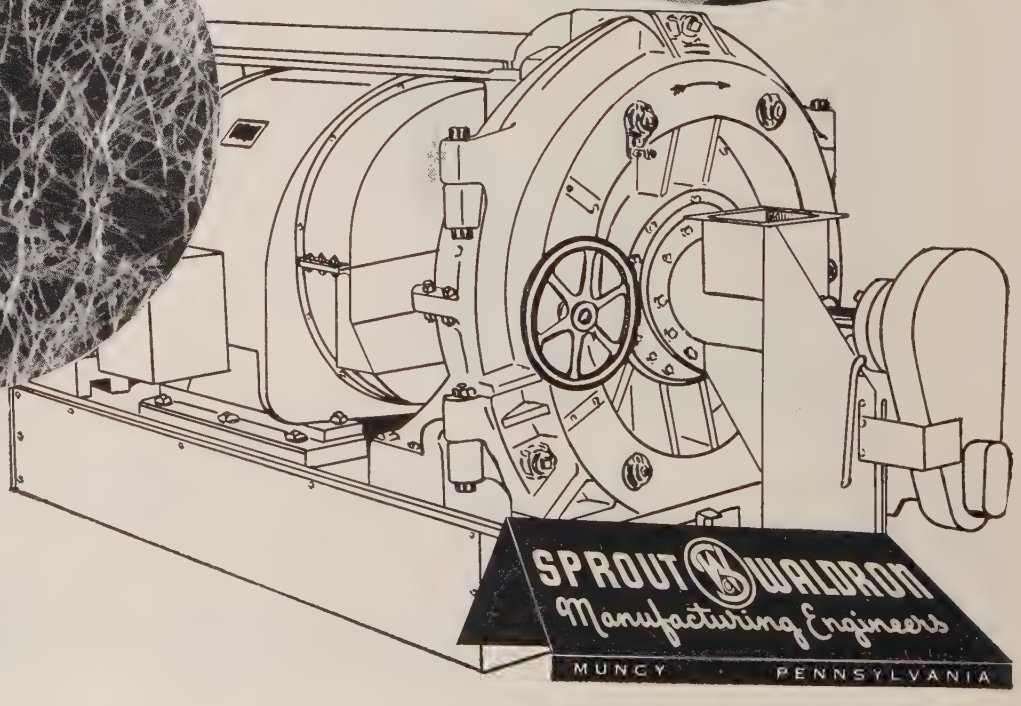

44-C

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than the *ROLLS* in it
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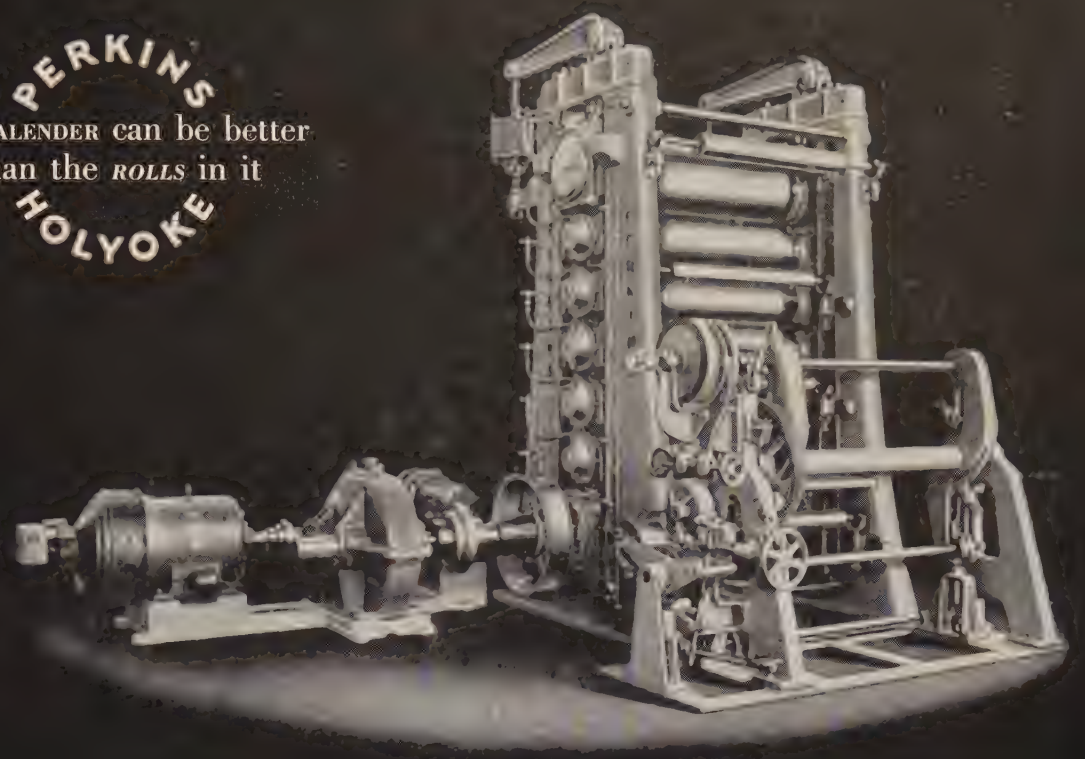

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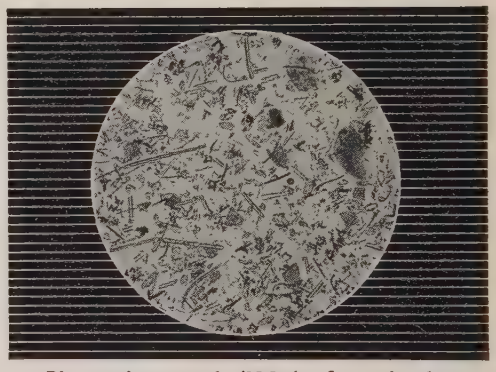
When the mat is deposited on the wire, the finely divided Celite particles, well dispersed among the fibres, fill the voids between the fibres, thereby producing a smoother surface finish. The superior quality of this finish is so readily apparent that potential buyers are quick to respond to its added sales appeal.

A Celite engineer will be glad to call and discuss this with you. He will also explain how you can improve drainage, speed up drying and realize other important advantages with Celite. Write Johns-Manville, Box 290, N. Y. 16, N. Y.



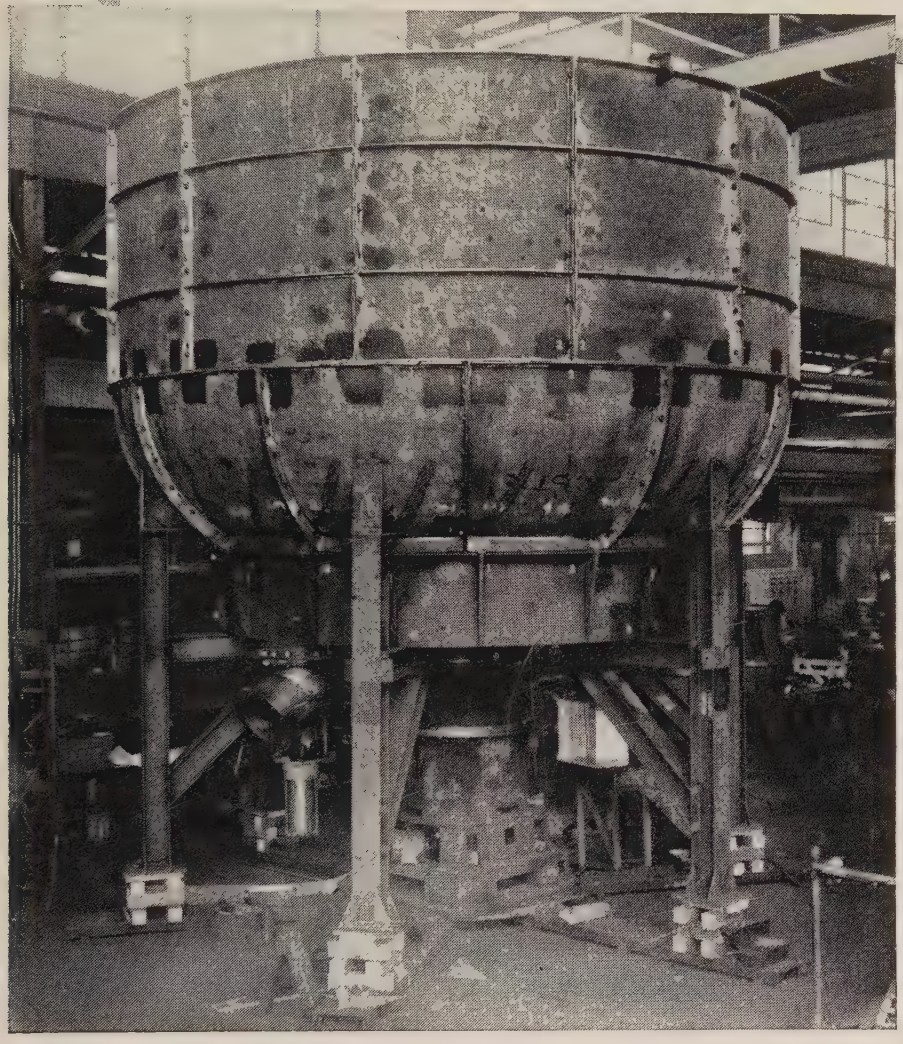
Photomicrograph (100x) of an air classified grade of Celite. This grade is widely used to improve formation, aid drainage and increase machine speed.

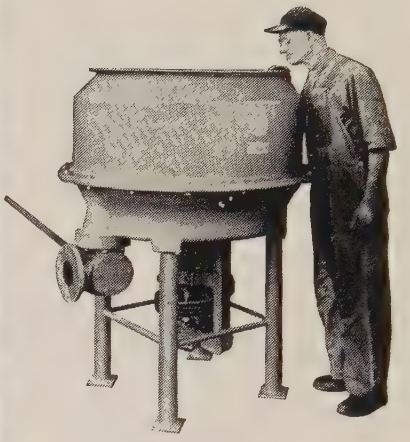
**Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.*

Johns-Manville CELITE PRODUCTS

for the paper industry

For Protection of paper products, both have Stainless-Clad Steel tubs





Laboratory Hydrapulper by Shartle Bros.; its 3-foot tub is Stainless-Clad Steel.

This Shartle Bros. Hydrapulper has an 18-foot tub made of Type 304 Stainless-Clad Steel. Erected at the Shartle Plant for checking and match-marking of parts prior to shipment to the mill, this Hydrapulper was shipped knocked-down, and assembled in the paper mill by welding.

No metallic contamination of materials processed in these Hydrapulpers! Only stainless steel—highly resistant to corrosive attack and abrasion—comes in contact with them. That stainless steel is permanently bonded to steel backing plate, giving the necessary structural stiffness and strength.

Lukens furnishes Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels to builders of equipment supplying your industry. Thus, those manufacturers are able to give you products offering all the advantages of these *solid* corrosion-resistant metals at the lower cost of *clad* steels.

Claddings are usually 10% or 20% of total plate thickness, depending upon the service on which they are to be used. All Lukens Clad Steels are available in the extra-smooth sodium hydride finish, making them extra easy to keep clean.

CLAD METAL STEEL

Ask your supplier to quote on equipment made of Lukens Clad Steels. And for more information on these materials, write for Bulletin 470. Lukens Steel Company, 501 Lukens Bldg., Coatesville, Pennsylvania.

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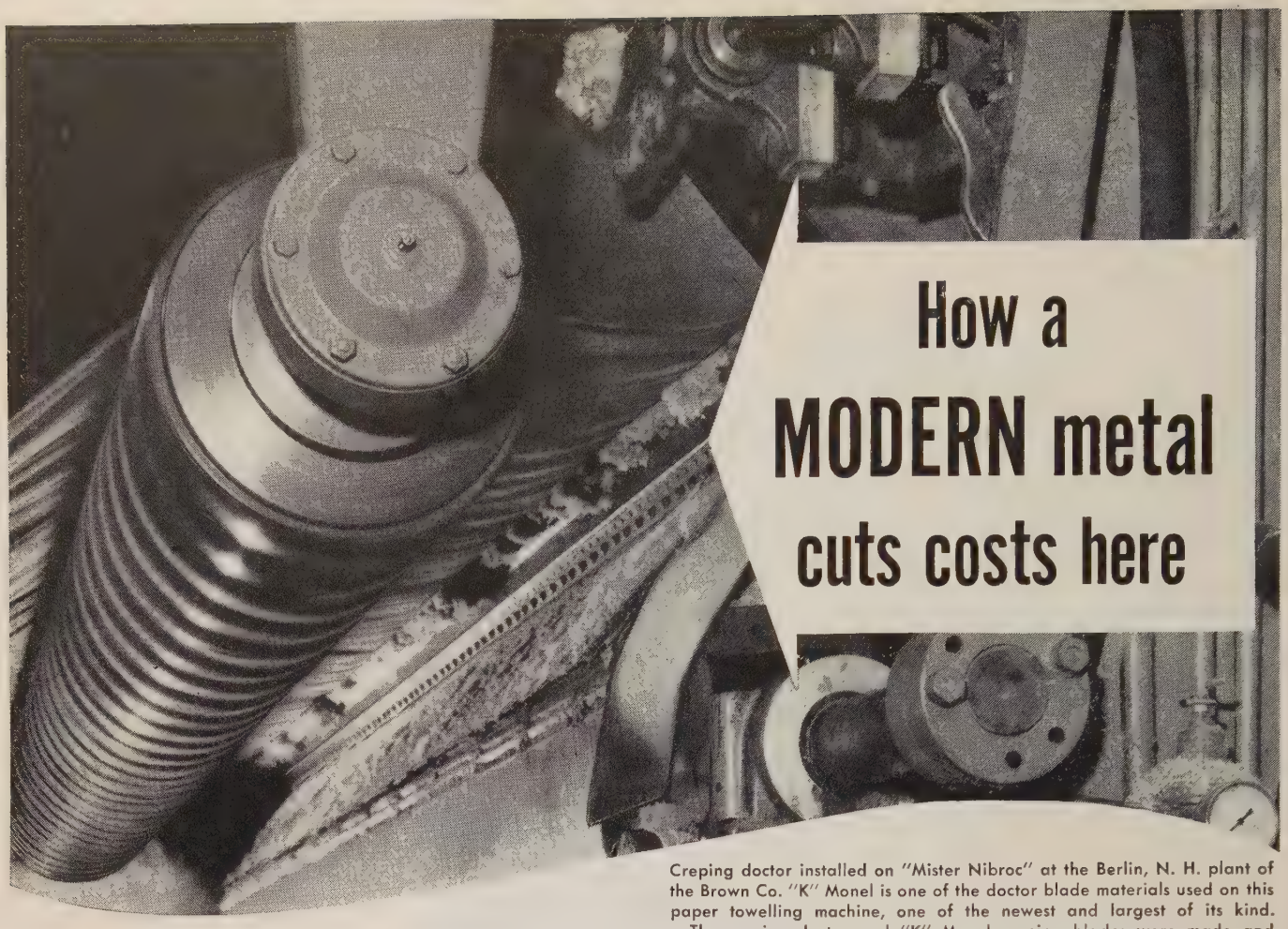
SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY



How a MODERN metal cuts costs here

Creping doctor installed on "Mister Nibroc" at the Berlin, N. H. plant of the Brown Co. "K" Monel is one of the doctor blade materials used on this paper towelling machine, one of the newest and largest of its kind. The creping doctor and "K" Monel creping blades were made and furnished by LODDING ENGINEERING CORP., Worcester, Mass.

Wear and corrosion...worst enemies of your doctor blades . . . *can* be controlled.

The secret of long-lasting, low-maintenance blades lies in using a metal that fits your operating conditions.

"K"* Monel is just such a metal. Consider its unique combination of desirable properties:

- **Non-rusting, highly corrosion-resistant.**
- **Strength and hardness greater than structural steel.**
- **Heat-treatable for maximum properties.**
- **Easy to machine; takes a high polish.**

So much for theory. Now . . . what about practice?

Many of the nation's busiest board and paper mills report outstanding service from "K" Monel doctor blades, in both dry and wet end applications.

"K" Monel blades, operating on modern high-speed paper machines, have given up to *18 times* longer service than blades of other commonly used metals. Less honing and less regrinding are required. Corrosion ceases to be a threat to blade life. Maintenance costs drop sharply.

Monel* has long been a preferred metal for many other paper mill applications, too . . . screens, save-alls, jordan bars, winding wire, head boxes, rolls and roll covers.

Why not investigate the money-saving possibilities of the versatile Inco Nickel alloys for your own Mill? A note to Inco will bring you full information. Write today!

* Reg. U. S. Pat. Off.

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MONEL*...FOR MINIMUM MAINTENANCE

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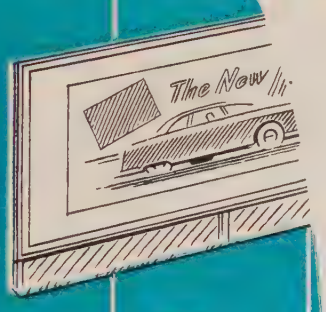
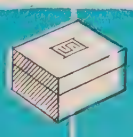
FINE printing is an art in itself, wholly dependent upon the skill of the craftsman-printer and the quality of the materials with which he works.

Variations of equipment, paper and press-room conditions require an intimate knowledge of each problem. Therefore, to supply the right ink for a specific purpose may mean practically a "prescription-filling" ink service. The companies listed below are prepared to give this service on inks for all printing processes.

Products of fine quality, service that is dependable, and good customer relations are characteristic of organizations that have a background of precision — both in manufacturing and thinking.





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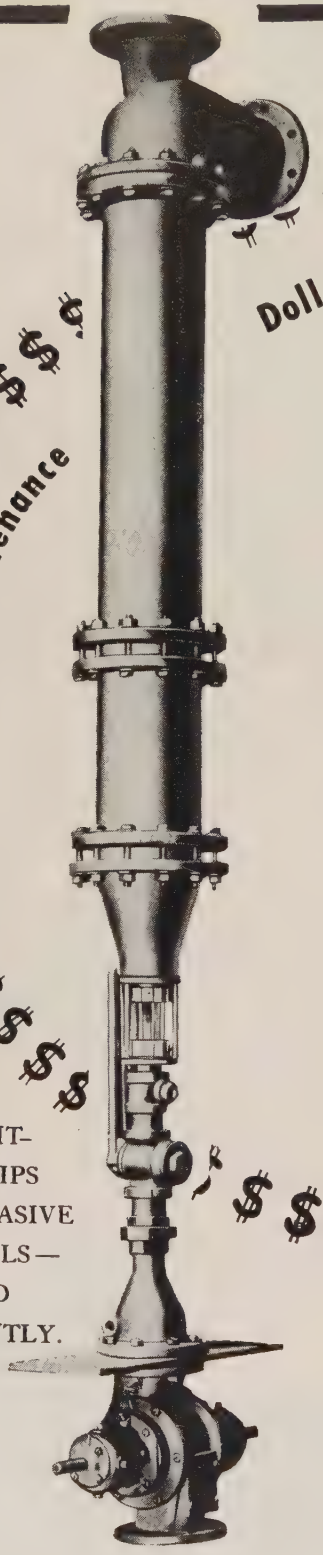

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A Maintenance

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REMOVED
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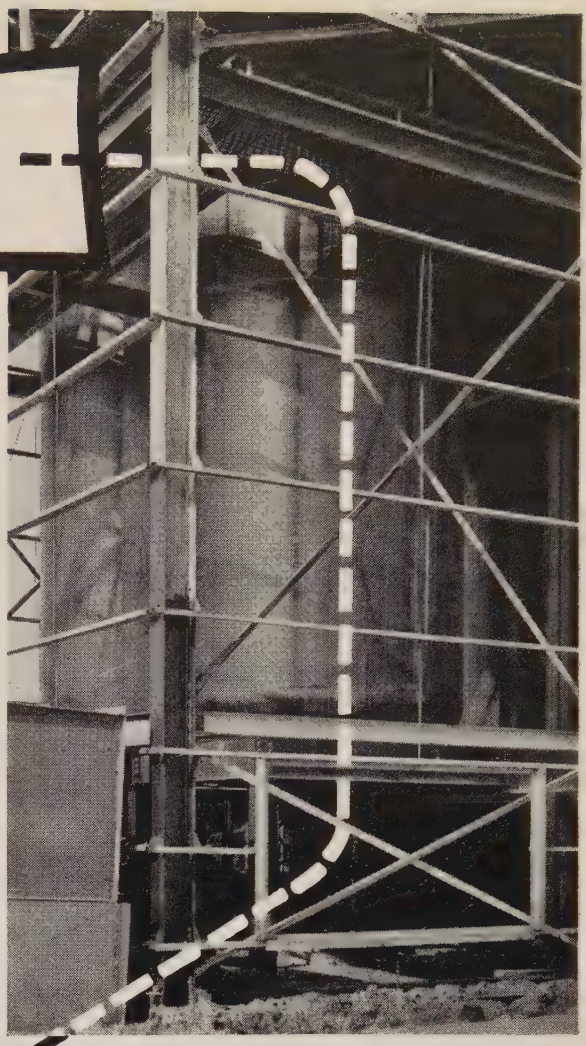
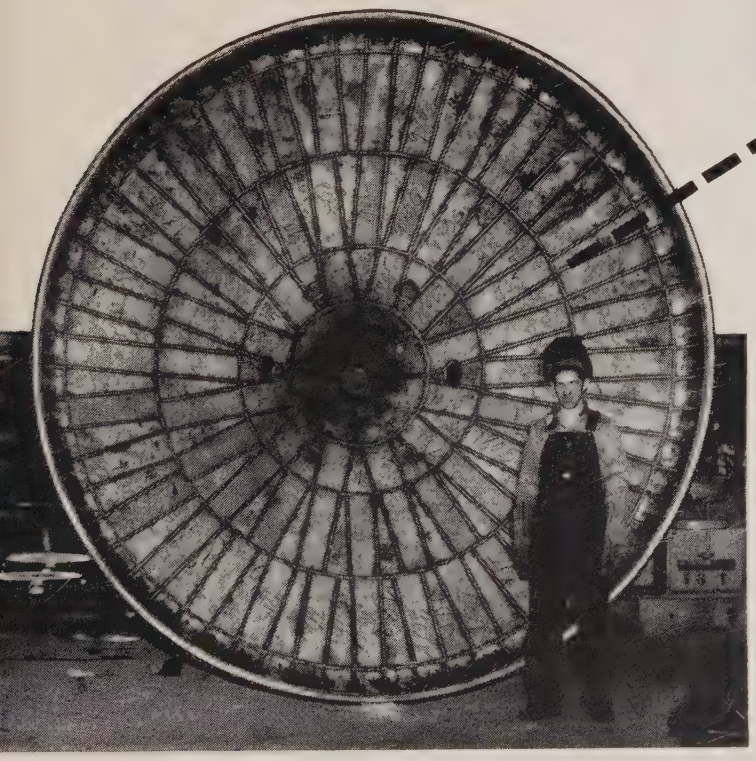
the Inside Story --

of Corrosion Control with Alloy Linings

You can frequently overcome many of the troublesome problems that accompany the handling of corrosive chemicals by taking an "inside" look at your storage tanks and process vessels. The right kind of corrosion-resistant lining, properly applied, may mean that you can greatly prolong the life of the vessel, avoid nasty cleaning and costly repairs, and eliminate the possibility of product contamination.

The view at the right shows four 11-ft. diam. digesters which we recently built for a pulp mill in Louisiana. The view below shows the bottom of one of these digesters. The bottom of all four digesters were lined with 18–8 Type 304 stainless steel to reduce corrosion. This view clearly illustrates a significant feature about alloy linings—their successful application requires skillful welders capable of welding alloy materials with alloy rods.





You get full service out of a corrosion-resistant material only if it is properly handled as the lining is installed. Our welders and technicians are experienced in working with these materials and are familiar with the problems encountered in applying them.

Select both the corrosion-resistant material and the fabrication method for your requirements from this group.

- Nickel, chrome, and stainless clad steels
- Nickel, chrome, and stainless steel linings welded in new or existing structures
- Non-ferrous alloys such as monel metal, aluminum, nickel and everdur fabricated into linings or entire vessels.

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Los Angeles, 14 . . . 1550 General Petroleum Building
New York, 6 . . . . . 3324 —165 Broadway Building
Philadelphia, 3 . . 1642—1700 Walnut Street Building
Salt Lake City, 1 . . . 1562 First Security Bank Building
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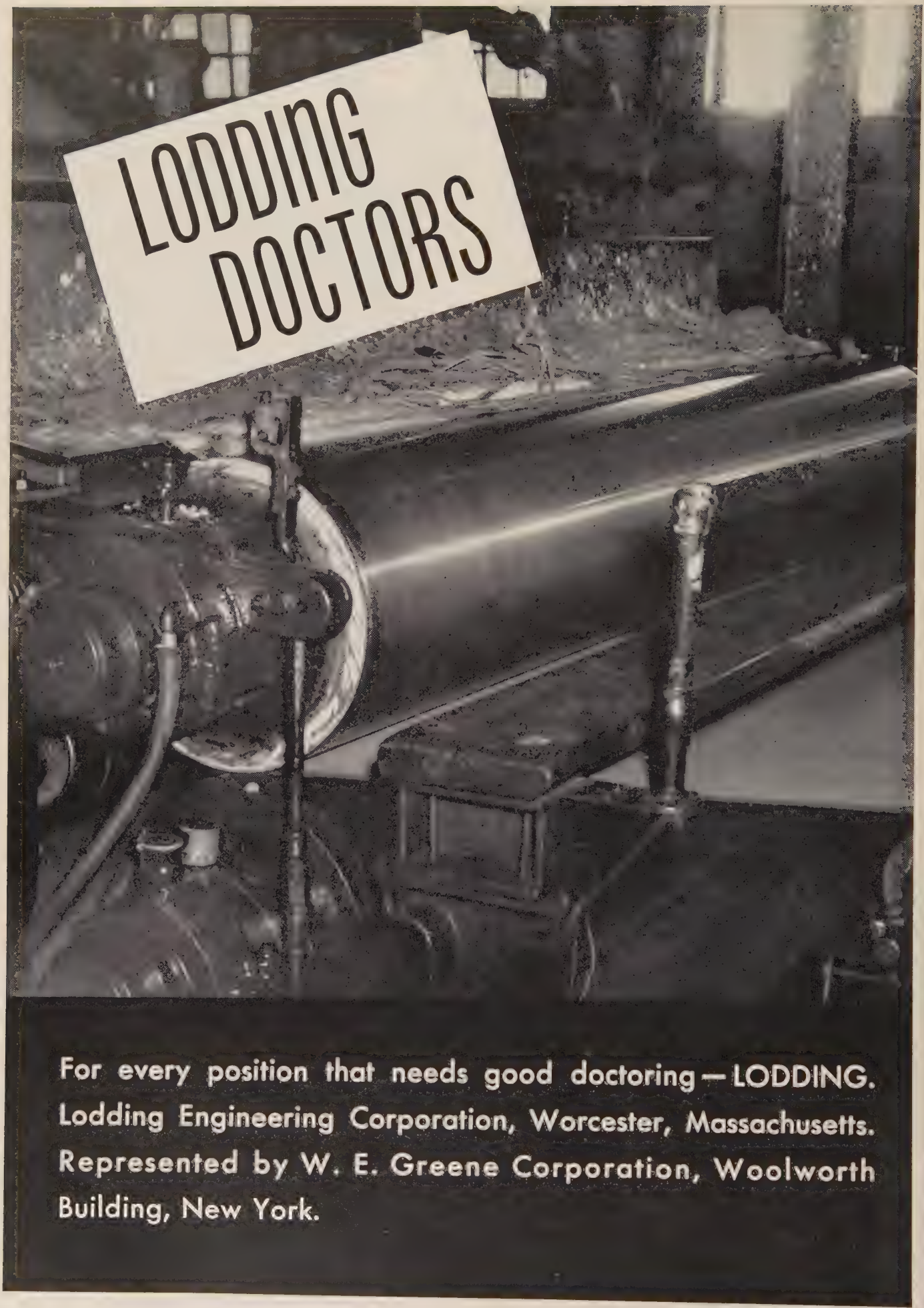
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Established 1886

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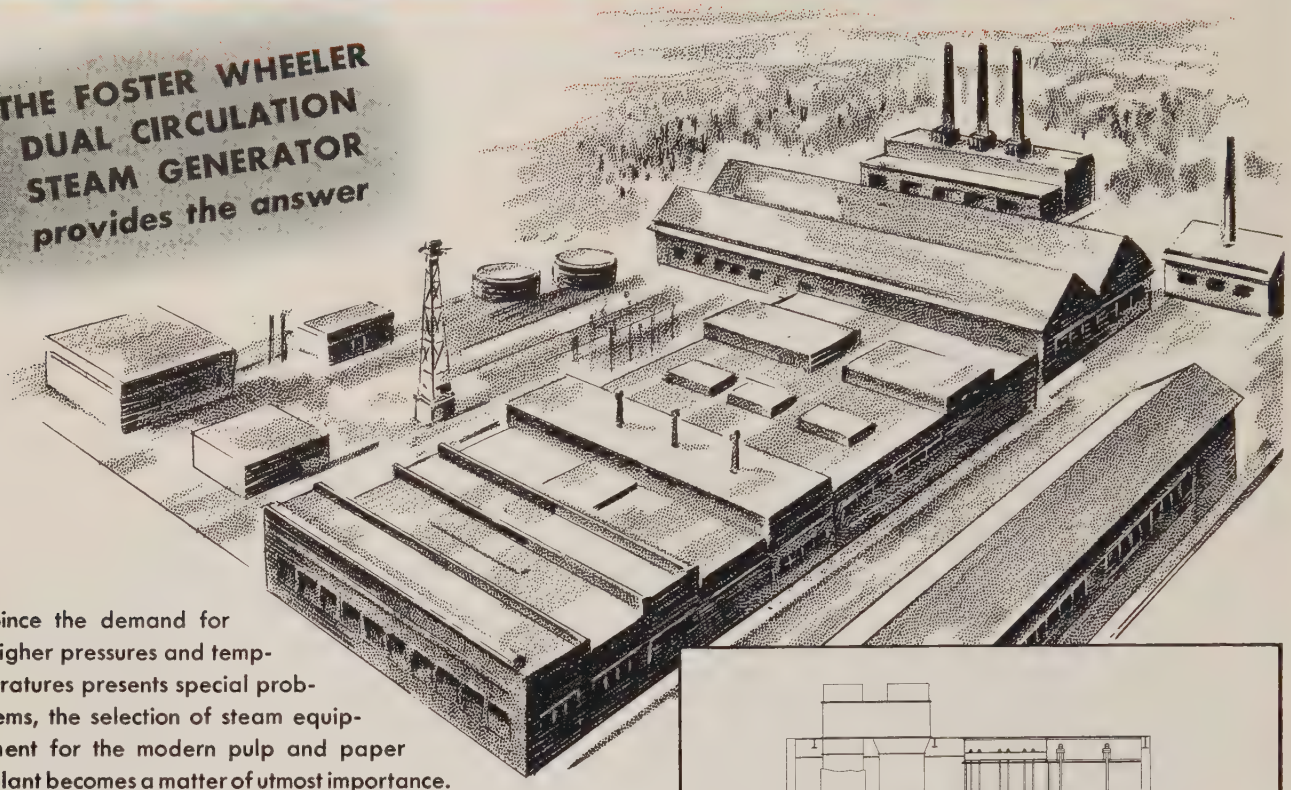
High Pressure Steam With High Make-Up?

THE FOSTER WHEELER DUAL CIRCULATION STEAM GENERATOR provides the answer



Since the demand for higher pressures and temperatures presents special problems, the selection of steam equipment for the modern pulp and paper plant becomes a matter of utmost importance. The Foster Wheeler Dual Circulation Steam Generator is now available to industrial plants requiring steam for both power and process. The advantages of this design with respect to reduced blowdown requirements and low maintenance have stimulated considerable interest among industrial plant operators.

STEAM PURITY

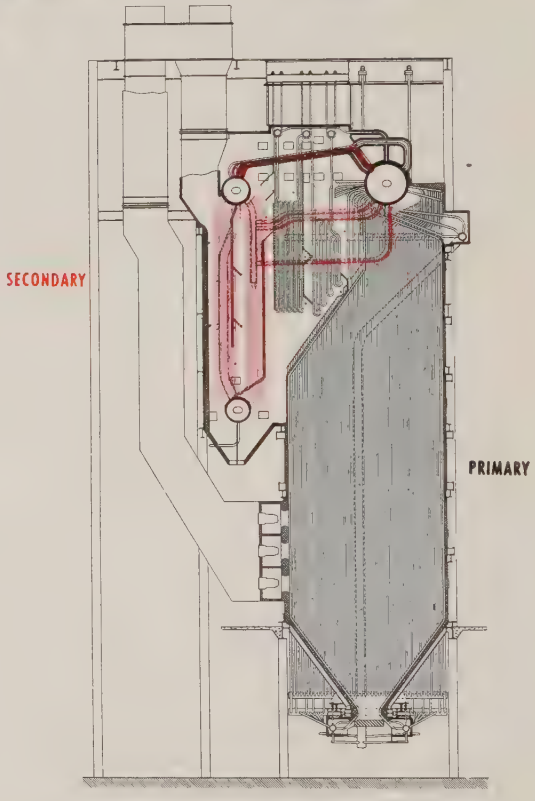
Even at high pressures and high feedwater make-up rates, the Dual Circulation Steam Generator substantially reduces carryover of both solids and vaporized silica below that of units of conventional design.

LOW HEAT LOSS

In most paper mills where conservation of water is a major consideration, the Dual Circulation Steam Generator enhances economical operation, with quantities of chemicals required for treatment processes maintained at a minimum.

LOW MAINTENANCE

Because silica carryover is negligible, forced outages to clean turbine blades, which normally collect silica deposits in the low pressure stages, will occur less frequently. Also by maintaining low concentrations in tubes subjected to highest rate of heat absorption, possibility of tube failures is minimized.



This Dual Circulation Steam Generator, designed for an industrial plant to operate at 1350 psi, 900 F with 100% make-up, has two separate heat absorbing sections, each with its own independent circulating system.

For detailed information, write:

FOSTER WHEELER CORPORATION
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FOSTER WHEELER ALSO DESIGNS, ENGINEERS AND ERECTS PULP MILL PROCESSING EQUIPMENT FOR TURPENTINE RECOVERY, INDIRECT DIGESTER HEATING, DIGESTER BLOW HEAT RECOVERY, AND TALLOL REFINING

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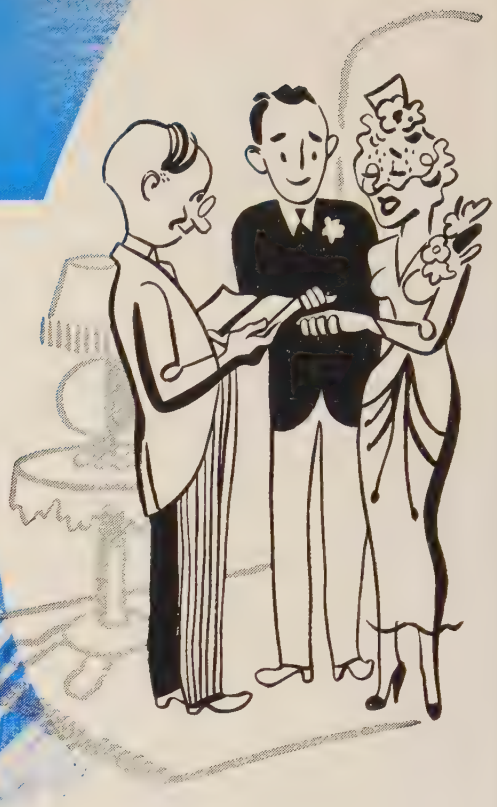
the Ideal Binder



No paper coating is better than its ability to bind to the stock. That's why an increasing number of important paper producers are turning to Methocel—the ideal binder for many specialty coating applications.

Methocel has an inherent ability to dry to a smooth, tough, clear, flexible film which binds clay and other pigments to paper and paper board. This exceptional film forming property is shown by Methocel's high sizing power to oils, greases and waxes. Light solutions of Methocel produce marked resistance to the penetration of gloss inks, varnishes, solvents and waxes.

Other useful qualities of Methocel to the paper producer are its efficient suspending power, highly useful in suspending pigment in colors; great thickening ability, valuable in control of latex viscosity; and excellent emulsion stabilizing properties.

Try Methocel as a better way of producing better paper products. Send in the coupon for your *free* experimental sample of the *new* Methocel, *powdered*.

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THE new *methocel*

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Dept. Me-750
Midland, Michigan

Please send free sample of METHOCEL, for use in _____

Check viscosity desired: 15, 25, 100, 400, 1500, 4000 cps.

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DOW

CHEMICALS INDISPENSABLE
TO INDUSTRY AND AGRICULTURE

Cutting and Welding in Paper Mill Maintenance

JAMISON MOORE

Maintenance is an important item in the operation of any paper mill. At Union Bag and Paper Corporation's Savannah plant, increased and improved use of cutting and welding has contributed materially to lower maintenance costs and better quality production. Equipment and methods have been standardized and auxiliary equipment installed as needed. New machines and processes have been investigated and adopted when proved to be of practical value. Men have been trained to develop versatile skills and safe habits of work. Management takes a continually progressive attitude toward the use of the most modern proved equipment and methods. Through these actions, the plant's maintenance department has been able to obtain longer life on machine parts, to handle successfully maintenance problems involving new materials, to overcome shortages of certain materials, to reduce lost time, and to reduce maintenance costs. While the cutting and welding procedures described here are being used in a large plant, the principles can be applied to a plant of any size with proportionate savings.

THE Savannah plant of Union Bag and Paper Corporation is perhaps the largest and the fastest growing mill of its kind in the United States. Starting twelve years ago with one paper machine and a small bag factory, this plant now has five 236-inch paper machines plus a large bag factory, box plant, paper processing department, and a byproducts plant.

As the mill has increased in size so has the maintenance department. Maintenance is, of course, an important item in the operation of any paper mill. With the volume of maintenance work required by the Savannah plant, it is evident that even small reductions in unit cost will result in considerable savings. Improvements in any single maintenance operation will have quite an effect on the total over-all maintenance cost. It is true that the equipment and procedures to be discussed in this paper represent those in use in a very large plant, but the same equipment and procedures can be adapted to smaller plants with proportionate savings.

Mechanical maintenance at Savannah is carried on through the medium of machine shops, millwright shops, a pipe shop, a garage, and a general maintenance shop. The author is assistant foreman of the general maintenance shop.

There are many ways in which this discussion could be presented covering the various procedures on cutting and welding in the Union Bag Savannah plant. It was decided to present it under three main topics: Cutting, Welding, and Related Processes based upon the normal and anticipated growth of the plant.

CUTTING

The number of hand-cutting torches in use has increased from two at the time the mill was started to 75 at present. Because there are repair jobs on large and heavy equipment, such as the barking drums, all of the more modern methods of plate preparation are used. On the heavy channels where cracks have appeared, gouging nozzles have been used to wash out the cracks and the channels have been repaired as good as new. The channels are fastened to the tire of the barking drum with rivets and after much pounding caused by the rotation of the drums, these rivets have to be renewed requiring the use of rivet cutting tips.

As the work increased for hand torches it was realized that a portable straight line and circle machine was needed. One was purchased, and later others were added. Today eight are in operation. These machines are used for cutting wear plates for conveyors, cutting plate for tanks, and fabricating both standard and special I-beam.

As the mill grew and maintenance responsibilities increased it was necessary to stock a greater quantity of plate in the mill to meet the repair schedule. This made it desirable to have a shape-cutting machine that would meet work requirements. A careful study was made of shape-cutting machines and one was selected that could cut sprockets up to 36 inches in diameter and irregular shapes up to 10 feet in length. This machine is equipped with three torches for multiple production of parts. Full scale drawings are employed in cutting sprockets, strip templets are used for repetitive jobs, and a magnetic head is used on large orders. Just recently it was necessary to cut a large sprocket for the coal conveyor to one of the power boilers. A large section of the sprocket was broken beyond repair and since at that time there wasn't another to replace it, it was a problem to fabricate one. The fact was evident that every extra day the conveyor was down it would cost the company an additional $600: this being the increase in the cost of fuel changeover from coal to oil. After checking the stock of plate, type 1045 steel plate $2^1/_2$ inches in thickness was selected for the job. Using the shape cutter to cut the plate, the sprocket was completed in 8 hours including the necessary machine work of boring the hub and cutting the keyway, netting a saving of over $300 on this job alone in the cost of fuel for the power boiler. The cutting of sprocket teeth, which formerly required as much as 8 hours by milling machine, now takes only 10 minutes on the shape-cutting machine.

An important step in lengthening the life of mill equipment and in making a better product has been made through the increased use of stainless and stainless clad steel on tanks, piping, pumps, and other equipment. The cutting of stainless and stainless clad at first presented quite a problem to the maintenance department. Investigation of various methods re-

JAMISON MOORE, Assistant Foreman, General Maintenance, Union Bag and Paper Corp., Savannah, Ga.

sulted in the purchase of powder-cutting torches for use on the shape-cutting and straight-line machines and of attachments to use on standard hand-cutting torches. This made cutting stainless steel comparable to cutting mild steel. As a result a large amount of equipment is now fabricated from stainless and stainless clad steel in the plant's maintenance shops.

WELDING

Pipes in sizes up to approximately 2 inches in diameter are still gas welded in most cases throughout the plant. Boiler tubes have frequently been repaired or, to use a shop term, safe ended, especially during the shortage of critical materials. The shops are equipped with oxygen and acetylene piped from manifolds and acetylene generators to better facilitate the use of such equipment. Many welding jobs have to be carried on in the mill and for this type of welding one man is stationed in the general maintenance shop part of whose duties is to receive telephone calls and to dispatch oxygen or acetylene to points requiring it with a minimum of lost time. This operator is also an expert repairer of torches and regulators.

Paper machine maintenance includes frequent repairing of damaged or broken castings. To meet certain chemical conditions some castings, such as pump housings and machine frames, are of cast iron, while many others are of bronze; thus both cast iron and bronze welding must be used. In addition, jordan bushings, sprockets, and other parts have to be bronze surfaced; for this purpose a harder type bronze rod than the type ordinarily used for bronze welding is used. For some jobs the bronze is heated and a shaft hammered to near size, reducing machining to a minimum.

The latest techniques in gas welding involve low-temperature welding which is used on many jobs such as steel, aluminum, bronze, and cast iron. Distortion can be held to a minimum because much less heat is required to get the desired results.

Electric welding began on a small scale in the plant with two small portable welding machines. Now 35 are in operation, including three portable gasoline-driven machines used to reach welding jobs where electric power is not available. Work such as tank fabrication, building and repair of conveyors, barking drum repair, pipe, stacks, vents, lime kiln repair, cooling system ducts, and structural steel for mill use on the buildings, cranes, and crane buckets, call for a wide variety of electrodes. A large stock of electrodes is stored in heated racks and bins for protection against moisture and dampness. This protection affords better welds and effects quite a saving in rod burn-off and waste.

An independent power supply for the welding machines was found to be necessary in order not to interrupt the operation of the mill and also to enable welding to be done during mill shutdowns. This system has been set up throughout the plant with safe type plug-in receptacles so that welders can be shifted from job to job with a minimum of lost time and the welding job done without power interruption. On wood yard conveyors, which are extremely long, repair jobs were speeded up by running welding cable in conduit along the conveyors with a plug-in receptacle every hundred feet. This installation also affords greater safety since it eliminated the former practice of stringing welding cable over high wood piles to reach the job to be done.

As the difficulties of getting sufficient amounts of certain materials increased, the different types of automatic welding machines were investigated to determine just how this equipment could be used. This study resulted in the purchase of one portable 1000-amp. Union Melt welding machine that operates off of two standard electric welding machines connected in series. This machine, which runs on 6-foot sections of interlocking track or on a standard 10-inch I-beam, makes long straight welds of better quality, and at a faster rate than is possible with manual welding. This makes it ideal for fabricating I-beams from plate salvaged from various jobs and also from standard stock plate. This type of welding complements machine cutting. With the two combined it makes a perfect set, as proper fit up is essential on all jobs.

The latest electric process is the heliarc welding, a type of electric welding where the arc is completely shielded by argon gas, making it possible to weld very light gage stainless, monel, aluminum, and other nonferrous metals. A large job recently completed with this type of welding was the building of saveall pans for two of the large paper machines out of 14-gage monel metal. These saveall pans are required on the fourdrinier of each machine and by fabricating out of monel a corrosion problem was met.

RELATED PROCESSES

A metal spray gun in Union Bag's Savannah Plant has been used very successfully on building up herringbone gear shafts where the slightest misalignment would have been fatal as far as the operation of the reduction gears on a paper machine are concerned. Some of these shafts that have been metallized are operating successfully after two and three years of continuous service.

Flame hardening is employed on many sprockets by using type 1045 steel and a 30-flame water cooled head. This head has tips of various sizes and plugs so that the flame can be adjusted to any particular job. The experience in hardening gear teeth is that the desired hardness for long service can be obtained and still have a tooth that will take plenty of punishment without breaking off. This process has increased by two or three times the life of many sprockets now in use throughout the plant.

Two stud welders, each operating off of a standard electric welding machine, are also in use. The principal application for these machines is the installation of pins to secure insulation material on tanks such as digesters, evaporators, and boiler tubes. In addition to these types of studs, good results in stainless-steel stud welding were gotten on certain jobs for the by-products plant, such as cladding condenser heads and installing stainless-steel linings in small tanks.

In the sheet metal department, the use of one small spot welder has resulted in a reduction in the number of rivets on light gage metal.

Wrinkle bending is used on pipe wherever it is considered practical and thus far its application to steam, water, and liquor lines has proved satisfactory.

Heavy heating is employed on various jobs as, for example, straightening large shafts, heavy plate bending, and stress relieving welds.

Since Union Bag and Paper Corporation's Savannah plant is still a young mill, having been in operation only twelve years, the author thinks it would be fitting at this time to discuss the future. An expansion program is underway, and this means that welding technology will be developed and expanded with the growth of the mill. We are looking forward, in the near future, to being able to do shape welding by using the Union Melt welding head on the shape-cutting machine. Also a welding positioner was recently obtained that will make it possible to broaden the scope of work to take in heavy flange welding and other heavy work.

There are many corrosion problems and in some places stainless clad steel or stainless steel liners are used. This will call for either heliarc spot welding or some other type of spot welder that will make it possible to get the desired results on tank lining.

Flame straightening is employed on many jobs and its use will be expanded.

Studies are now being made on the possible advantages of using flame priming in the maintenance of a fleet of steel barges used in transporting a part of the plant's pulpwood supply. It is thought that this process will contribute to the increased life of the barges by providing better and cleaner surfaces for painting.

There are indications that a larger shape-cutting machine may be required in the near future to handle more efficiently anticipated increased demands for heavier equipment to be built by the maintenance department.

Pressure welding is also being investigated to see how many present jobs it can be applied to and if future work quality may be improved by this type of welding.

MEN

Up to this point the discussion has been confined to machines, equipment, and methods. No paper on this subject would be complete, however, without mention of another highly important ingredient—men —the human element. A maintenance department is no better than the man who performs the actual maintenance work and the men in management who furnish leadership to those who are charged with seeing that maintenance work is properly done.

Training directed toward the development of versatility of skills rather than in single skill is a definite part of our maintenance operations. Through a system of rotation and training, both welders and helpers become familiar with all types of work. Whenever new processes are introduced, all the men eventually are trained in their use. Consequently, the plant is better prepared to handle emergencies and peak demands for certain types of work than would be possible if only a specialist or two were developed in each line.

This training on the job is supplemented by meetings and classes, held in cooperation with the plant training department. The purpose of the courses is to develop a better understanding of welding procedures and directly related skills. It is interesting to note that practically all welders and helpers have attended, voluntarily and on their own time, meetings at which welding films are shown and discussed, and that a large percentage of the men have voluntarily completed courses in blueprint reading.

Supervisors also come in for their share of training, not only in the technical end of the work, but also in the fundamentals of working with and directing people on the job.

SAFETY MEASURES

Safety is another important consideration in the training, protection, and development of the men. Job training is conducted on the basis that the safest way to do a job is the correct way to do it. In addition, the plant safety department has available at all times a full line of safety shoes, safety glasses, goggles, and other safety equipment designed to offer the greatest possible protection for each job. The safety department cooperates with supervision in a continuous campaign of safety education, hazard elimination, and other measures to make the plant a safer place in which to work.

Particular attention is given to the fire hazard which may be caused by the torches, especially on work done outside the shops. Although all the portable welding buggies are equipped with fire extinguishers, the fire protection department is always notified when a welding or cutting job creates any possibility of fire. The fire protection man sets up screens of asbestos drier felt, provides fire hose, and fire extinguishers for prompt use, and takes whatever other steps that are necessary to safeguard the area.

The combination of training and safety activities has resulted in a well-trained, versatile, safety-minded, and resourceful crew of maintenance workers.

These activities contributed greatly in a recent major maintenance performance—the installation of a new headbox weighing 78,000 pounds, designed for increased production on one of the paper machines. This job was completed a day ahead of schedule without a single accident.

The things that have been done with cutting and welding in our maintenance work could not have been accomplished, however, without the progressive leadership and encouragement of the men who make up the management of Union Bag. The organization is constantly striving for improvement in machines, equipment, methods, and men.

SUMMARY

To summarize, the cutting and welding activities which have been described have contributed to lower maintenance costs and to increased quality and quantity production. It is true that the equipment and procedures mentioned are used in a large plant, but it

is believed that these can be applied to any plant with proportionate good results. In our own case, it has taken lots of hard work and study; the application of machines, equipment, and methods to suit the needs; and the development and protection of men—all with the full support and encouragement of management. It is believed that progress has been made but it is known that there is much still to be done as new techniques are developed and proved.

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DISCUSSION

Hubert F. Parker (Maintenance Engineer, New York & Pennsylvania Co., Inc., Lock Haven, Pa.): Mr. Moore has described the equipment that is used for cutting and welding in a very large maintenance department of a large pulp and paper mill. He stated in this description that "the equipment and procedures mentioned"—"can be applied to any plant with proportionate good results." In a broad sense this is true for the alert maintenance man either knows where, close at home, he can have done those operations he is not equipped to handle himself, or he sees to it that the parts most likely to be needed in an emergency are on hand in the maintenance storehouse. It can be contended that such a procedure is not the most economical, in that a profit is paid when work is done by others and/or interest charges build up on items carried in the stores house.

For the smaller mills where the quantity of work to be done is not great enough to keep the various tools reasonably busy it is without doubt more economical to rent the use of the machines and hire the services of skilled operators from an organization whose major business it is to do job welding and fabrication since others help to carry the investment and depreciation charges on the tools and share in the labor costs.

Exactly the same is true of the materials that are carried in the storehouse with the addition of interest charges on the investment over the period of time they are held in storage.

In moderate sized mills the answer to how much of the type of work Mr. Moore described is to be carried out by the maintenance department depends on the management's decision of whether or not they are willing to get into a business quite foreign to their primary business.

However, no mill, no matter how small, can any more afford to be without a cutting torch, a welding torch, or an electric welder, than it can afford to be without an electric drill, a drill press, a lathe, a saw bench, an efficient hydraulic wheel puller, or the blacksmith's forge and anvil, for they are labor-saving tools.

The simplest cutting torch finds untold uses from separating stubborn nuts and bolts; cutting off bars, angles, or structural shapes; heating pieces to be bent or straightened; to cutting out intricate shapes in pipe or plate.

An inexpensive tool that can be added to the cutting-torch group is the powder cutting blowtorch which permits cast iron to be cut as easily as the cutting torch cuts steel.

The welding torch finds many uses in putting together broken castings of all types and descriptions from the simplest of shell-like pieces to very large parts with heavy sections. It is an extremely useful tool in the building in of teeth broken from the face of a gear, or the jointing of dissimilar metals. Where the welding torch is used, it is necessary to preheat the work, keep it hot while working on it, and permit it to cool very gradually.

A portable electric welder having a capacity of 250 to 300 amperes can do a vast amount of work from assembling simple structural parts to take the place of cast parts to putting together complicated gallows frames and other structural work. More and more piping is being welded together in the mills and many complicated pipe elements and fittings that formally required very expensive and time consuming patterns are now being fabricated quickly and inexpensively. Many parts that suffer from abrasion and require frequent replacement can be made to last much longer by the simple process of hard surfacing the soft metal.

Admittedly some of the operations mentioned above cannot be done as economically as with the tools previously discussed, but it is amazing what a skillful operator can do with good torches and a good electric welder.

However, a word of caution should be sounded for there are certain operations where these tools should not be used. The cutting torch should never be used to melt babbitt from bearing boxes, yet this is an operation common to many mills and industries. The welding torches, either gas or electric, should not be used to build up the journals of rotating elements, unless the shop is equipped to stress relieve the part after welding. Many broken journals of the fatigue fracture type have been traced directly to such welding. This operation can far better be performed by metallizing, which does not set up strains in the journals, and which has been used very successfully on both large and small journals.

While it may not be economical for a mill to purchase and install most of the special cutting and welding equipment, it is highly advisable that they hire only top-notch men who can perform skillfully vast quantities of complicated work quickly and economically without large investments in special equipment. These men should be certified operators so that they can work on pressure vessels in accordance with the laws of many states and the regulations set up by the insurance companies.

From the foregoing it appears that many mills do not need to make large investments in cutting and welding equipment, but that these mills should have along with their other labor-saving tools, cutting and welding torches, and an electric welder, which should be used by the highest-skilled operators obtainable so that maximum value can be obtained from the equipment available, leaving the very large and/or very complicated jobs to be done by those outside shops whose business it is to do that kind of work. The mill should also plan ahead to have on hand those parts which, should a breakdown happen, would be very crippling if none were available.

Spray Drying Coefficients for Sulphite Waste Liquor

H. H. FOGLER, F. HERBOLZHEIMER, R. M. STINCHFIELD, L. C. JENNESS

Sulphite waste liquor at a concentration of 25% solids was spray dried in a tower drier, and at concentrations of 8, 24, and 45% solids in a laboratory spray drier. Flue gas at temperatures of 300, 400, 500, and 600°F., was used as the drying medium in both pieces of equipment. A method of calculating an over-all heat transfer coefficient for the vaporization of water is proposed. Values of this coefficient are presented on a volumetric basis for a mean temperature driving force between the dry bulb and wet bulb temperatures of the heating medium. These coefficients are found to decrease for the laboratory drier with an increasing concentration of solids in the liquor. The tower drier was operated with the spray and gas in parallel and in countercurrent directions. A higher coefficient resulted from countercurrent operation, the value of which was close to that obtained with the laboratory unit.

SPRAY DRYING is an operation that has been practiced for many years. It is only recently, however, that it has received particular attention. The production of dehydrated foods during the last war was an impetus for much of this attention and resulted in advancing the mechanical features of spray drier construction more than it enlightened the science of drying.

One of the objects of the investigation being presented was the preparation of pilot plant quantities of spray-dried solids from sulphite waste liquor. A commercial drier not being immediately available, the construction of a spray drier was undertaken. A survey of the literature presented suggestions that were useful in designing equipment and pertinent references (*1–6*) are listed in the bibliography appended. No published information could be found, however, that would allow a prediction of the capacity of spray drying equipment from the standpoint of volume of spray chambers required for various conditions of operation. The desirability of more basic information on the science of spray drying is further evidenced by a research program at the University of Wisconsin reported on by W. R. Marshall, Jr., at the November, 1948, meeting of the American Institute of Chemical Engineers. Marshall described the construction and operation of standard driers and enumerated phases of spray drying that should be more extensively studied.

The authors had hoped that information would be available from which a relationship between spray chamber volume and the temperature of the drying medium could be evaluated, as valuable as that which exists for the rate of heat transfer through surfaces:

$$Q/\theta = q = UA\Delta t_m \qquad (1)$$

in which Q/θ is a rate of heat transfer through the area, A, caused by a mean temperature driving force, Δt_m. The over-all heat transfer coefficient, U, is then expressed in units of Btu./hr.×sq. ft.×°F.

No such satisfactory relationship for spray drying could be found in the literature. The comparable relationship for spray drying should be:

$$Q/\theta = q = KV\Delta t_m \qquad (2)$$

in which Q/θ would be the rate at which heat is utilized by the evaporation of water in a spray chamber of volume, V, caused by a mean temperature driving force Δt_m. The over-all heat transfer coefficient, K, would then be in units of Btu./hr.×cu. ft.×°F. and might be dependent on the efficiency of mixing of the fluids or on the type of spray utilized since the surface area of droplets per unit weight of liquid increases with a decrease of size of droplets.

It was expected that the temperature driving force would be a logarithmic mean temperature difference between the dry bulb temperature of the drying medium and the temperature of the droplets being dried, which should be substantially the wet bulb temperature of the drying medium. The validity of the log mean Δt is shown by the following derivation based on the assumptions of adiabatic operation and constancy of coefficient.

For a differential interval of volume, equation (2) may be written:

$$dq = K(t - t_w)dV \qquad (3)$$

Furthermore, the heat change dq is equal to the change of sensible heat of the gas stream, G, of humid heat, s; i.e.,

$$dq = Gsdt \qquad (4)$$

Eliminating dq from equations (3) and (4) yields,

$$Gsdt = K(t - t_w)dV \qquad (5)$$

NOMENCLATURE

A	=	area in sq. ft.
G	=	quantity of drying gas in lb.
K	=	coefficient of heat transfer in Btu/(hr.)(cu. ft.)(°F.)
p.s.i.	=	pounds per square inch gage pressure
q	=	rate of heat transfer in Btu./hr.
Q	=	quantity of heat in Btu.
θ	=	interval of time in hr.
s	=	humid heat in Btu./lb. °F.
t_1	=	inlet temperature of drying gas in °F.
t_2	=	outlet temperature of drying gas in °F.
t_w	=	wet bulb temperature of drying gas in °F.
Δt_m	=	log mean temperature difference between dry bulb and wet bulb temperatures of drying gas in °F.
t_f	=	feed temperature in °F.
U	=	coefficient of heat transfer in Btu/(hr.)(sq. ft.) (°F.)
V	=	volume in cu. ft.

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Separation of the variables and integrating gives,

$$Gs \int_{t_2}^{t_1} \frac{dt}{t - t_w} = K \int_{V_1}^{V_2} dV \qquad (6)$$

The evaluation of which results in,

$$Gs \ln \frac{t_1 - t_w}{t_2 - t_w} = KV \qquad (7)$$

From the integrated form of equation (4),

$$Gs = \frac{q}{t_1 - t_2}$$

which if substituted in equation (7) yields,

$$q = KV \frac{(t_1 - t_2)}{\ln \frac{(t_1 - t_w)}{(t_2 - t_w)}} \qquad (8)$$

Equations (2) and (8) are then identical if the temperature driving force is expressed as a logarithmic mean. This relationship is comparable to that for adiabatic humidification, a process which is necessarily complementary to spray drying.

A tower type spray drier was constructed, therefore, in order that the volumetric capacity could be measured in terms of an over-all heat transfer coefficient.

EQUIPMENT AND OPERATION

Tower Drier

The drying chamber, shown in Fig. 1, consisted of a cylindrical section of sheet steel about 2 feet in diameter and 8 feet in height. The tower had a flanged, removable top and a removable plate at the bottom of the cone for discharge of solids. Preheated sulphite waste liquor could be supplied under pressure to gun-type atomizing nozzles located near the bottom or top of the tower as shown in Fig. 2. Flue gas from an oil-fired furnace was drawn by a suction blower to the top of the tower, which it entered tangentially, and subsequently through a cyclone separator. Thermometer wells were inserted in the liquor feed line and in the exhaust gas line close to the tower. The inlet gas temperature was controlled by bleeding in atmospheric air and the temperature of the gas entering the tower was measured by a thermocouple. The spray heads that were used had such a small angle of divergence that there was no direct impingement on the walls of the tower.

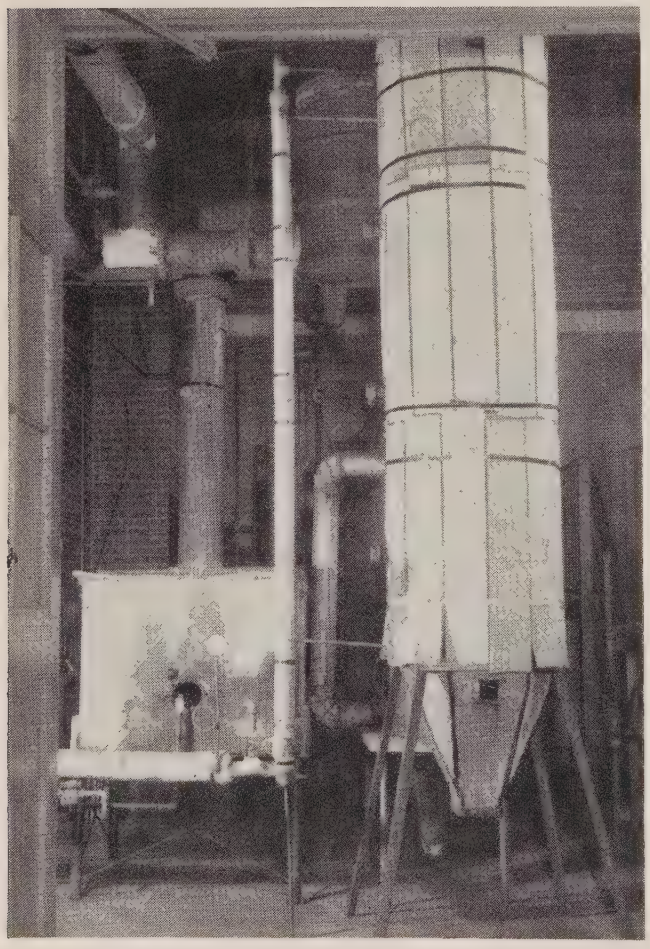

Fig. 1. Tower spray drier and furnace

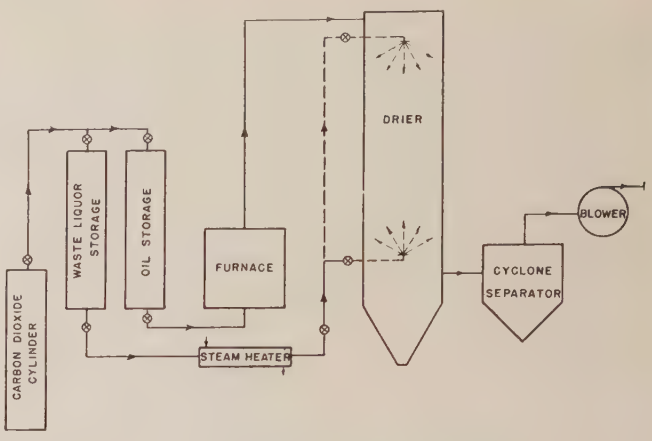

Fig. 2. Line diagram of tower spray drier

In operation the equipment was first thoroughly heated. Preheated waste liquor of a given per cent solids was then sprayed to the tower either countercurrent to, or in parallel with, the gas stream. After steady-state conditions resulted, the liquor feed rate was measured from the storage cylinder and the necessary temperatures were recorded for a period of $^1/_2$ to 1 hour. The capacity of the blower was measured with an anemometer. The humidity of gas entering the tower was computed from flue gas analyses and the composition of the fuel oil.

At the end of each run the bulk of the solids had collected in the base of the tower cone although some adhered to the walls of the tower. The moisture content of the solids was determined, and the amount of water evaporated was computed from the rate and composition of the liquor feed. The net amount of heat required to vaporize this water was substituted in equation (2) with the tower volume and the existing logarithmic mean temperature driving force. The values of over-all heat transfer coefficients so computed are tabulated as results.

Laboratory Drier

Later in this investigation a Bowen laboratory spray drier became available and it was operated to pre-

pare other samples of dried solids and to allow the evaluation of heat transfer coefficients. This drier, shown in Fig. 3, consists of a gas-fired burner, a drying chamber, a centrifugal atomizing device, a cyclone particle collector, and an exhaust fan.

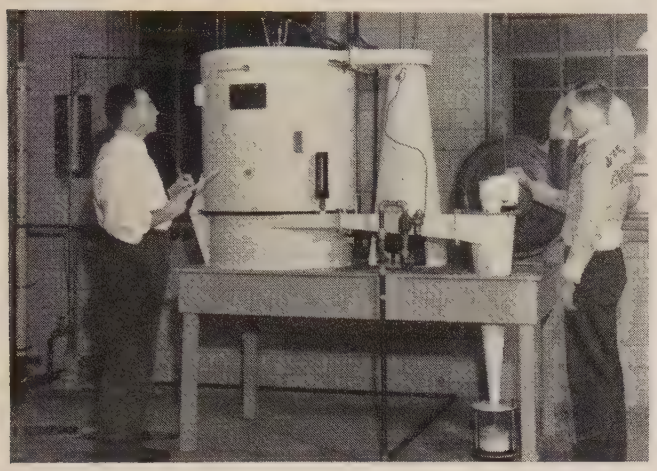

Fig. 3. Laboratory spray drier

Flue gas from the burner, which was supplied with commercial fuel gas, was used as the drying medium, and its temperature was regulated by a Partlow thermostatic temperature control. The drying chamber, lined with stainless steel, was 30 inches in diameter and 30 inches in height. The hot gas entered the top of this chamber through a vaned inlet that circulated the gas in a counterclockwise direction when viewed from the top of the chamber. This rotation of the drying gas tended to prevent particles from adhering to the wall and increased the time of contact of them with the heating medium. Thermometer wells were located in the inlet and outlet drying gas lines.

Atomization of feed in this drier was accomplished by the centrifugal action of a stainless steel wheel, located in the vaned inlet and rotated at 50,000 r.p.m. by a pneumatic turbine motor. Compressed air was supplied to the turbine from a Kellogg-American air compressor at 95 p.s.i.g. and a rate of 10 to 12 c.f.m. The dried solids were carried by the gas stream to a cyclone separator where they settled out in a glass receptacle. The exhaust gases were discharged by a medium pressure blower to the atmosphere at a rate which was measured with an anemometer.

In operation of this unit the equipment was first thoroughly heated and then brought to steady state with a water feed at a rate slightly less than one that allowed wetting of the chamber walls. Sulphite waste liquor was then supplied as feed and the necessary data observed to allow the calculation of a heat transfer coefficient as previously described. A series of runs was made at inlet drying gas temperatures of 300, 400, 500, and 600°F., for waste liquor concentrations of 8, 24, and 45% solids. The values of heat transfer coefficients that were computed are tabulated as results.

DISCUSSION OF RESULTS

The observed data on drier operation are tabulated in chronological order: Table I for the tower drier, for which runs one to four, inclusive, were used to develop procedure and technique of operation; Table II for the laboratory drier, for which runs 13 to 15 are not shown for the same reasons.

Table I. Tower Drier—Observed Data

Volume of Drier = 20.45 cu. ft.

Run No.	Type feed	Solids, %	Temperature, °F. —Inlet t_1	Outlet t_2	Feed— t_f	Feed rate, lb./min.
5	Countercurrent	25	403	280	130	0.306
6	Countercurrent	25	362	218	124	0.458
7	Countercurrent	25	338	224	165	0.353
8	Countercurrent	25	460	248	158	0.840
9	Countercurrent	25	568	319	142	0.418
10	Parallel	25	495	289	140	0.399
11	Parallel	25	559	374	115	0.306
12	Parallel	25	435	321	122	0.189

The calculated data for each run and the coefficients of heat transfer obtained are further tabulated. Table III is for the tower drier in which the order of runs has been rearranged within the groups of type of feed; i.e., countercurrent or parallel, in the order of increasing inlet gas temperatures. Table IV is for the laboratory drier, in which the order of runs has been rearranged to group concentrations of solids in increasing order, and within each group in the order of increasing inlet gas temperature.

Table II. Laboratory Drier—Observed Data
Volume of Drier = 12.24 cu. ft.; Parallel Feed

Run No.	Solids, %	Temperature, °F. —Inlet t_1	Outlet t_2	Feed— t_f	Feed rate, lb./min.
16	8	504	170	150	0.304
17	8	600	220	176	0.210
18	8	305	130	122	0.210
19	45	498	195	156	0.300
20	45	310	150	136	0.132
21	45	582	217	173	0.364
22	45	413	187	156	0.137
23	24	320	148	132	0.148
24	24	402	162	147	0.328
25	24	491	190	156	0.211
26	24	597	202	161	0.197
27[a]	24	597	202	161	0.197
28	8	400	163	141	0.228

[a] Atomization wheel operated at 40 p.s.i. air pressure.

A comparison of heat transfer in a spray drying chamber to that in a heat exchanger will explain further presentation of results. In heat transfer between fluids indirectly through an area, the entire area is necessarily effective, terminal temperatures adjust themselves correspondingly, and the over-all coefficient of heat transfer is dependent on capacity only to the extent that individual film coefficients are affected by changes in velocity of flow. Heat transfer in a spray chamber is not analogous. If not operated at maximum capacity, the drying is accomplished in a portion of the volume and hence the entire volume is not effective. For this reason, it was intended to operate the drier at maximum capacity during each run, thereby allowing the solids to remain at the wet bulb temperature of the drying medium throughout the entire volume.

A number of runs, however, resulted in either a wet product or a wetting of the walls of the drier. Results from these runs were regarded as invalid for obvious reasons and are so indicated in Tables III and IV. On the other hand, for many runs it was considered that the drier was not operated at capacity, and a comparison of inlet temperatures and feed rates between various runs indicates that such a conclusion is warranted.

time it would be in the constant and the falling rate portions of a drying rate curve. The curve should, of course, approach zero at 100% solids. For the other extreme of zero concentration of solids, it should approach the value of the coefficient for water in adiabatic humidification to which it would be entirely analogous. Badger and McCabe (7) have given values from 90 to 95 for this coefficient.

It is logical to assume that the size of the sprayed

Table III. Tower Drier—Calculated Data and Results

Run No.	Type of feed flow	Temperature, °F. Inlet t_i	Temperature, °F. Wet bulb t_w	Temperature, °F. Log mean Δt_m	B.t.u. transferred per lb. water evaporated	Pound water evaporated per min.	K B.t.u./(hr.)(cu. ft.)(°F.)
7	Countercurrent	338	135	136	987	0.247	5.3
6	Countercurrent	362	136	142	1028	0.336	7.1
5	Countercurrent	403	138	198	1023	0.224	3.4
8[a]	Countercurrent	460	...	...	...	...	...
9	Countercurrent	568	147	279	1015	0.418	4.5
12	Parallel	435	140	234	1032	0.189	2.5
10	Parallel	495	143	234	1015	0.399	5.1
11	Parallel	559	146	311	1042	0.306	3.0

a Result invalid because of incomplete drying.

A study of Table III shows that there is no apparent correlation of heat transfer coefficient, K, to the inlet temperature of the drying gas, or to the driving force Δt_m. In general, however, countercurrent operation gave higher coefficients than did parallel operation. A study of Table IV also shows that there is no apparent correlation of coefficient to the inlet gas temperature nor to the driving force, Δt_m, but that there definitely is a correlation of coefficient to concentration of solids in the feed.

In the light of these observations and the previous discussion concerning capacity of operation, it was decided that the maximum values of coefficient obtained for each concentration of feed for the laboratory drier, and for each type of feed flow for the tower drier, were the pertinent values for this investigation.

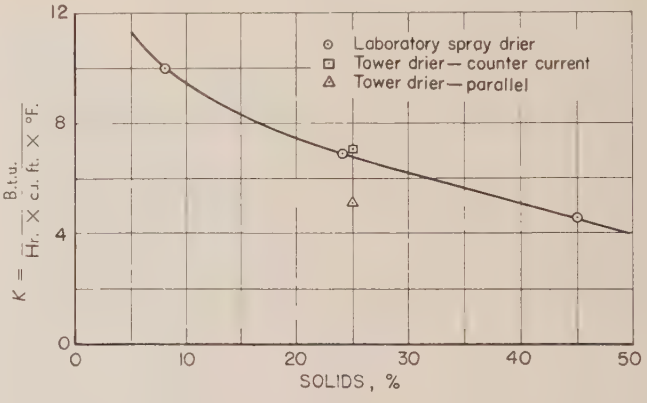

Fig. 4. Heat transfer coefficient K vs. waste liquid concentration in per cent solids

Table IV. Laboratory Drier—Calculated Data and Results

Run No.	Solids, %	Temperature, °F. Inlet t_i	Temperature, °F. Wet bulb t_w	Temperature, °F. Log mean Δt_m	B.t.u. transferred per lb. water evaporated	Pound water evaporated per min.	K B.t.u./(hr.)(cu. ft.)(°F.)
18[a]	8	305	...	...	...	...	...
28	8	400	132	110	1010	0.208	9.4
16	8	504	138	137	1003	0.278	10.1
17	8	600	143	214	979	0.192	4.3
23	24	320	126	81	1016	0.110	6.8
24[a]	24	402	...	...	...	...	...
25	24	491	137	166	997	0.157	4.6
26	24	597	143	194	994	0.146	3.7
20	45	310	125	79	1013	0.068	4.3
22	45	413	133	138	995	0.071	2.5
19	45	498	138	165	997	0.155	4.6
21	45	582	142	206	982	0.188	4.4

a Results invalid because of incomplete drying.

Figure 4 presents these optimum values in which the coefficient is plotted versus the concentration of solids in the feed.

It will be noted that the coefficient decreases with increasing concentrations of feed. That this should be so is logical when one considers the individual droplet of water and solids, and the relative lengths of droplets would have considerable effect on coefficients of heat transfer obtained. This investigation does not uphold such an assumption. The values obtained in the tower drier in which a pressure nozzle gave relatively large droplets compared to the atomization obtained by the centrifugal wheel of the laboratory drier, are not far removed from the curve in Fig. 4,

particularly for countercurrent operation. This observation is further supported by the results of run No. 27, in which the only change from run No. 26 was that the centrifugal wheel was operated at 40 p.s.i. air pressure rather than the normal 95 p.s.i. to give a slower rotation of the wheel and larger resultant droplets. The operating data and coefficients of these two runs were identical.

The solid product from the tower drier was in general not very hygroscopic, black in color, and of relatively large particle size; e.g., a considerable portion would not pass an 80-mesh screen. The solids from the laboratory drier were quite hygroscopic, brown to dark brown in color, and of very small particle size; e.g., the majority would pass through a 200-mesh screen.

ILLUSTRATIVE PROBLEM

The following problem is postulated to illustrate the utilization of over-all heat transfer coefficients for the computation of spray drier volume necessary to dry a commercial quantity of concentrated waste liquor.

Capacity of mill	= 100 tons pulp/day
Raw waste liquor, 8% solids	= 100,000 lb./hr.
Concentrated waste liquor, 45% solids	= 17,800 lb./hr.
Spray-dried solids (6% moisture)	= 8510 lb./hr.
Water evaporated	= 9290 lb./hr.

Assumptions:

Drying gas from combustion of No. 2 range oil
Humidity of drying gas entering = 0.074
Inlet gas temperature = 1000°F.
Outlet gas temperature = 250°F.
Feed temperature at wet bulb temperature, of drying gas
Driving force, $\Delta t_m = 330°F.$
Heat to be transferred = 9.29×10^6 Btu./hr.
Coefficient of heat transfer, $K = 4.6$ Btu./hr. $\times$ cu. ft. $\times$ °F.

Volume of drier $\frac{9.29 \times 10^6}{4.6 \times 330} = 6130$ cu. ft.

Dimensions of drier approximately 20 ft. in diameter by 20 ft. high, or 17 ft. in diameter by 25 ft. high

CONCLUSIONS

1. Heat transfer coefficients for the spray drying of sulphite waste liquor, in the laboratory drier utilized, decrease with increasing concentration of solids in the liquor.

2. The difference between pressure type atomization and rotating wheel atomization has little effect on heat transfer coefficients within the range of this investigation.

3. Pressure type atomization and tower drying yielded a product of larger particle size and one that was less hygroscopic than resulted from the laboratory drier

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Logging and Pulping Black Spruce Thinnings

Z. A. ZASADA and C. A. RICHARDSON

A study was made on the feasibility of using small diameter black spruce from thinnings in which logging and pulping cost were analyzed. The cost of producing wood from thinned stands is higher than in regular operations and logging costs are also higher, but the operation is still practical. The small wood requires slightly more handling in the pulp mill, but operations are not necessarily slowed down, and the yield and quality of the pulp are satisfactory.

A PROBLEM of concern to the paper industry and forest managers in Minnesota is how to extend the present black spruce pulpwood supplies. Stands of this species now are being cut at a rate of more than 200,000 cords per year. The maximum annual drain allowable if the resource is to be permanently maintained is 80,000 cords. The area of black spruce stands cannot readily be increased, but closer utilization of the remaining mature stands can help to extend the supply. This phase of the problem has been studied intermittently during the last seven years.

In 1941, the Minnesota Division of Forestry and the Minnesota and Ontario Paper Company, made a cooperative study (*1*) in which the cost of utilizing 8-foot and 4-foot black spruce pulp sticks to a $3^1/_2$-inch top was compared with utilization to a $1^1/_2$-inch top. A mature stand of spruce was logged for this project. No mill data were collected concerning the suitability of the small wood for manufacture of pulp. The results of the study showed that (1) yields from a stand of black spruce timber can be increased substantially by reducing top utilization specifications, and (2) closer utilization increases production costs.

During the 1946–1947 logging season a second study (*2*) of closer utilization of mature spruce stands was

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undertaken. This study, made near Big Falls, Minnesota, compared the yields and cost of utilizing black spruce to a 4, 3, and $2^1/_2$-inch top diameter. In this case mill tests were made on the wood to determine what effect closer utilization might have on pulping by the sulphite process. This study showed that it is practicable to extend the present supply of merchantable timber by utilizing black spruce pulpwood to a $2^1/_2$-inch top when cut from mature stands. The resulting extra volume can offset the small additional logging costs. It was also found that the small wood obtained on this operation did not reduce the quality of sulphite pulp produced.

To examine further the possibilities of obtaining additional spruce pulpwood from present stands, a third utilization study was undertaken in 1948. Its purpose was to determine the practicability of producing pulpwood by thinning black spruce stands of small diameter, and to determine whether this pulpwood could be used successfully in the manufacture of groundwood pulp. This study is reported here.

It is recognized at the outset that to make thinnings commercially feasible, the minimum pulpwood merchantability would have to be lowered from present standards of a 4-inch top. This is so because a large number of the trees in the stands available for cutting will not produce pulpwood sticks sufficiently large to meet present minimum standards, and as much pulpwood as possible would have to be removed in order to get sufficient volume to make the operation financially successful. For this study it was agreed that a minimum top diameter of 3 inches would be acceptable. This permitted the cutting of trees as small as 3.8 inches in diameter breast high.

It was recognized further that a mill test would be necessary to find out whether the wood from the thinning operation, which contains a high volume in sticks under present merchantable sizes, could be processed and used successfully in the manufacture of pulp. Accordingly a mill test was set up as a part of this study.

The project was a cooperative undertaking. The Chippewa National Forest, through its regular sale procedure, provided a stand of black spruce suitable for thinning on the Cutfoot Sioux district of that forest. The timber was sold to the M. J. Salisbury Company (timber producer for the Blandin Paper Company) who provided for the logging. The Blandin Paper Company processed the wood and collected the mill data. The Lake States Forest Experiment Station planned the project, supervised the woods operation, and collected the logging cost data.

Four small tracts, comprising 37 acres of 75-year-old black spruce swamp stands were selected for the thinning study. The area was laid out in strips 100 feet wide. Trees to be cut were blazed with an axe. The volume cut per acre varied from 2 cords on some strips to 8 cords on others. Two small areas making up less than an acre were marked for clear cutting because of mistletoe infestation. The average cut per acre over the whole area was 3.92 cords.

Normal methods for winter logging on small operations were used. Cutting was done on a piece-work basis. Skidding, loading, and hauling were contracted by the cord.

Cost and time records for cutting and skidding were kept for each operation. Records were also kept on the cost of road maintenance, snow plowing, making of landings, etc.

Since the adjoining areas had been logged during the past ten years, all tracts were readily accessible. No large expenditure was required for new roads. Road and landing costs consisted of cleaning out windfalls and brush from old roads and landings with a bulldozer.

The wood from the thinning was processed as one lot at the paper mill. Records were kept of the time and power needed for processing the wood, the pulp yield, and the volume shrinkage due to barking. These data were compared with records for regular mill-run wood.

COST OF LOGGING

Cutting Operation

The cutter's job was to fell the tree, buck it up into 100-inch lengths at the point of felling, trim the branches from the stem for the full usable length of the tree (to a 3-inch top), cut a skid trail through the center of the strip, and pile the wood in small piles along the skid trail. No lopping of slash was required.

The rate of pay on this operation started at 5 cents per stick for the sticks under 4-inch top, 7 cents for sticks 4- to 7-inch top, and 11 cents for sticks over 7-inch top. The pay rate was raised during the course of the cutting to 7 cents for sticks under 4-inch top, 9 cents for sticks 4- to 7-inch top, and 11 cents for sticks over 7-inch top. The union rate for cutting spruce pulpwood during the time of this operation was 4 cents for sticks 3- to 4-inch top, $6^3/_4$ cents for sticks 4- to 7-inch top, and $11^3/_4$ cents for sticks over 7-inch top.

The 101.05 cords of wood on which cutting time records were kept were made up of 5240 sticks under a 4-inch top, 4380 sticks 4- to 7-inch top, and 137 sticks over 7-inch top. The total cost of cutting this wood under the last piece-rate paid on the job would be $776.07, or a cost per cord of $7.68. Under the union rate this cost would have been $521.35.

Six hundred and ninety-eight man-hours were required to cut the 101.05 cords of wood, or 6.91 man-hours per cord. Under the piece rates paid on the operation the earnings for cutting were $1.11 per hour. Earnings under the union wage scale would have been 75 cents per hour. This would be 18 cents below the minimum hourly wage rate of 93 cents set up in the Union Wage Contract for the 1947–1948 logging season.

Raising the pay rate to the high-point set toward the end of the operation was necessary for reasons other than cutting small trees and a low volume per acre. Heavy snow early in 1948 made it difficult for cutters to work in the woods. In order to keep the men on the job a high piece-rate for cutting had

to be established. It is the opinion of those who supervised the operation that had it been carried out under more normal logging conditions, the piece-rates first set up would have been satisfactory. This would have given a cutting cost per cord of about $5.78.

The data collected in this study show that the cost of cutting pulpwood in thinning operations, where light cuts per acre are made, will be higher than in operations where mature timber is cut. Under the union piece-work rate, cutters cannot produce sufficient small size sticks per hour to meet the minimum union hourly rate. Therefore, a rate higher than that given in the union contract is necessary to keep cutters on the job. The results of this study approximate those of the Big Falls study made in 1947 (*2*). On this job, with 3.92 cords cut per acre, 6.91 man-hours were required per cord; on the Big Falls job 6.4 man-hours per cord were required for a cut of 5 cords per acre. In both cases utilization was to a 3-inch top diameter.

Skidding Operation

The skidding was done by two men using a single horse and dray. Loading wood onto the dray from piles along the skid trail and from the dray onto piles at the landings was done by hand. The average dray load was approximately $^1/_2$ cord. Skidding distances averaged 400 feet and varied from 100 feet to 1200 feet. This operation was contracted at the rate of $4.25 per double cord.

Time records kept on the skidding of 30.77 cords from one 10-acre block showed a total of 76 man-hours or 2.47 man-hours per cord. Cost of skidding this wood under contract rates was $65.39. This was divided as follows: Labor cost—$57.79, horse cost—$7.60. Skidders on this job earned about 76 cents per hour.

The low rate of production per man-hour can be attributed to several factors: (1) the deep snow made it difficult to break out skid trails. The first few loads out of each strip had to be light dray loads. (2) The light cut per acre did not permit full use of the skid trails after they were broken out. (3) Two men working with one horse instead of a team made for poor use of time. Too much time was spent walking between landing and wood piles in strips. In the Big Falls study where 5 cords per acre were cut, 1.04 man-hours was required per cord for 2 men using a team and a dray with a capacity of 1 cord. It is believed that light cuts per acre will increase skidding costs over the contract rate used in this study even under more normal snow conditions, but not to the low production rate per man-hour which is indicated here.

Loading, Hauling, and Unloading

No data were collected on the loading, hauling, and unloading phase of this operation. The study carried on at Big Falls, Minnesota, during the 1946–1947 logging season showed that utilization to a small top diameter does not affect materially the costs of these operations for hand loading and unloading of spruce pulpwood. This is confirmed by the fact that the operator contracted this job at the same rate as other pulpwood hauling in the general area of the thinning operation which was $4.50 per cord.

Other Costs

The areas cut over for this study were accessible from roads used in logging the mature, adjacent timber. A large area of other immature stands is accessible because of similar conditions. In this case the expenditures for roads, snow plowing, and clearing of landings were: roads and snow plowing, $70.00; landing costs, $25.00.

The operator paid the following taxes and insurance on labor costs for cutting and skidding:

	Per cent
Social security	1
Job insurance	2.67
Workmen's compensation	8
	11.67

Cost Summary

Logging costs were itemized so as to compare the costs of pulpwood production by thinning with an operation in a mature spruce stand cut for pulpwood (Table I). The mature stand was cut in connection with a utilization study carried out at Big Falls, Minnesota, during the 1946–1947 logging season. In the Big Falls operation the volume cut per acre in the 3-inch top utilization amounted to 20.71 cords as compared to 3.92 cords per acre in the present study. The wood at Big Falls averaged 70 sticks to the cord, and in the thinning operation, 104 sticks per cord. Logging conditions, particularly in regard to snowfall, were much more favorable during the logging at Big Falls than at the time of the thinning operation.

Table I. Itemized Cost Per Cord of Pulpwood from Thinning an Immature Stand and That from an Operation in a Mature Stand (3-Inch Top Utilization)

Item	*Cost per cord — Thinning operation Cutfoot Sioux, dollars*	*Cost per cord — Regular operation Big Falls, dollars*
Cutting	7.68	4.47
Skidding	2.13	1.68
Loading, hauling, unloading	4.50	4.50
Taxes and insurance	1.11	0.81
Roads and landings	0.66	0.86
Other indirect	...	0.33
Total	16.08	12.68

Under a market price of $20 per cord for black spruce pulpwood, which existed during the 1947–1948 logging season, an operator would have $3.92 per cord for stumpage and margin for profit in the thinning operation and $7.35 per cord in the regular operation.

MILL STUDY

Wood Comparison

The wood from the thinning operation was cut from trees ranging from 3.8 to 8 inches in diameter at breast height. The average diameter was 4.9 inches. Except for number of sticks per cord this wood compared very favorably with mill-run spruce obtained under 4-inch top utilization (Table II).

Table II. Comparison of Black Spruce Wood from Thinnings and Regular Mill-Run Wood

Kind of wood	Amount per cord: Sticks, No.	Amount per cord: Solid wood,[a] cu. ft.	Wood density per cubic foot, lb.	Moisture content, %
From thinnings	104	104.5	26.5	43.4
Regular mill run	58	105.0	25.6	43.0

[a] The cubic volume is for 50-inch wood.

An analysis of the scale records of the wood produced in the thinning operation showed the following size distribution:

	Per cent
Sticks under 4-inch top	54.0
Sticks 4- to 7-inch top	44.7
Sticks over 7-inch top	1.3
Volume in sticks under 4-inch top	46.0
Volume in sticks over 4-inch top	54.0

Barking of Wood

Bark was removed with a drum barker. Records on 144.96 cords showed the following results as to barking time and shrinkage:

	Wood from thinning	Regular mill wood
Barking time, hr. per cord	0.28	0.35
Shrinkage, %	18.8	19.7

Actually there was little difference in barking time between regular mill run wood and the wood from the thinning operation. For plant operation reasons, extra help was being used in the wood room at the time the thinning wood was barked and therefore it was put through at a faster rate.

The shrinkage in volume as a result of barking is a comparison of the scale of wood on trucks at the time of delivery and the scale of wood after bark removal and cutting into 25-inch lengths as measured on carts at the grinder.

Grinding and Yield

The wood was ground on four-pocket grinders, using 25-inch wood. The grinders were individually powered by 1000 horsepower motors. Power consumption and output of two grinders were recorded (Table III).

Table III. Results of Grinding Tests of Black Spruce Wood

Grinder number	Power consumption: Thinning, kw. hr.	Power consumption: Regular, kw. hr.	Power consumption: Thinning, hp.-days	Power consumption: Regular, hp.-days	Pulp produced per hour: Thinning, lb.	Pulp produced per hour: Regular, lb.	Pulp freeness: Thinning, ml.	Pulp freeness: Regular, ml.
11	1246	1225	70	68	962	1018	70	64
13	1000	1070	56	60	1108	1084	80	75

Because of the greater time required to feed pockets when using the small size wood the load on the motors was reduced about 6% as judged from kilowatt-hours used in 24 hours. This reduction in load probably can be eliminated by using a three-pocket instead of a four-pocket operation.

The pulp from the thinnings had the same strength and fiber length as pulp from regular spruce.

Further tests on the processing of this wood showed the following comparisons:

	Regular Wood	Wood from Thinning
Density, lb. per cu. ft.	25.6	26.5
Weight, bone dry per rossed cord, lb.	2580	2770
Yield, air dry per rossed cord, lb.	2750	2955
Yield, air dry per rough cord, lb.	2210	2400

This shows that wood from the thinnings was greater in density and yield than regular mill-run spruce. This conforms with results of a utilization study made at the Minnesota and Ontario Paper Company at International Falls, when $2^1/_2$-, 3-, and 4-inch top utilization were compared (*2*). The chemist at this plant remarked that the wood utilized to a smaller top diameter had the higher yield. It might be assumed that the small trees and tops which are cut under close utilization have a high wood density which will compensate for the extra cost of handling by giving a higher than normal yield. This is a factor which merits further study.

CONCLUSIONS

1. By utilizing black spruce to a small top diameter it becomes practical to thin immature stands for pulpwood production.
2. Costs of producing wood from thinned stands where light cuts per acre are made were found to be higher than in mature stands where large volumes are cut per acre. However, the increase in cost is not sufficient to price the wood out of the market under present conditions of supply and demand for spruce pulpwood.
3. Because of higher production costs in thinning operations, the logger cannot afford to pay usual stumpage prices to the landowner. However, with the wood prices and costs which prevailed in 1947–1948, he can pay enough to cover the landowners costs of timber marking and supervision of cutting, plus possibly an additional small amount. This, together with the fact that the thinning will improve the stand and increase later yields, makes the operation a desirable one for the landowner.
4. Mill studies showed that the pulp yield and quality from the small wood was little different from that obtained from wood purchased under present specifications.
5. Small wood requires more handling in grinding and barking, but the extra handling is not sufficient to slow down the processing operations.
6. A major part of the volume of wood produced in thinning will meet present wood specifications. In this study 54% of the volume was in sticks 4 inches top diameter and larger.
7. A thinning program will add to present wood supplies by (a) utilizing the mortality which occurs in unmanaged stands, and (b) improving growing conditions for the residual stand and thereby increasing the yield.

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The Presence of Arabinose Units in Pinewood and in Kraft Pulp

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Arabinose, in small amounts, has been found in the hydrolyzates of the following pines: sugar pine (*P. Lambertiana* Douglas), western white pine (*P. monticola* D. Don.) and Virginia pine (*P. virginiana*, Miller). Its presence was shown both chromatographically and by the formation of its characteristic diphenylhydrazone. Thus, it is impossible to differentiate between the "five-needle" and the "two-needle" pines on the basis of their arabinose content. Arabinose was absent from the hydrolyzates of a commercial unbleached spruce sulphite pulp, but was found in the hydrolyzate of a commercial unbleached jack pine sulphate pulp. This presents evidence that, in at least one case, arabinose units are present in the cell walls of a coniferous wood.

ALTHOUGH xylose residues (present in the cell-wall polysaccharides of many fibrous raw materials) far exceed those of its isomer arabinose, the latter is also widely distributed in small amounts in grasses, straw, and in various woods. To give a few specific examples, Davis and Phillips (*1*) found that the hemicelluloses of sugar cane on hydrolysis gave one mole of arabinose to every 22 moles of xylose; Weihe and Phillips (*2*) found that the hemicelluloses of wheat straw gave rise to about 0.9 mole of arabinose to every 23 moles of xylose. These same investigators (*3*) found that cornstalk hemicellulose showed the molar ratio of arabinose to xylose of 7:19. A classical example of arabinose units brigaded in small amounts with xylose units is that of esparto pulp. In the "xylan" from this raw material the ratio of arabinose to xylose units was about 1:20 (*4*). That arabinose is found in many of the coniferous woods has been known for many years. An outstanding case is that of western larchwood, in which the arabinose forms a portion of the water-soluble arabogalactan and in which the unextracted wood may yield 1 to 2% arabinose on hydrolysis (*5*). Much smaller amounts of arabinose are also obtained from other common larches (*6–8*), from jack pine (*9*), and from black spruce (*10*). In every case in which woods were examined, the arabinose units were present among the water-soluble extractives of the raw material. Apparently they have never been reported definitely among the cell wall components (e.g., the wood hemicelluloses). This does not preclude their presence in certain wood pulps.

Arabinose units which have the L-arabinofuranose configuration can be removed far more readily by acid hydrolysis than can most of the other simple sugars. Treatment with very dilute acid or even with water under pressure for relatively short time periods serves to remove free arabinose. Hence, the appearance of the free sugar in any wood extract (with a pH below 7) is no criterion of its original presence *as such in situ*. It simply indicates that arabinose units (possibly arabans) were present in the wood. Recently, Stockman and Hägglund (*11*) showed that the "arabans" of spruce (*Picea excelsa*) were quantitatively hydrolyzed with distilled water at 120°, giving yields of 0.7 to 0.8% arabinose based on the original wood. Judging from this work, it would appear that arabinose units would probably never be found in sulphite pulp. On the other hand, in hard kraft pulps their presence might well be suspected. These hypotheses find experimental support.

EXPERIMENTAL

A preliminary study was made with three pines in the hope of differentiating between the so-called soft pines ("five-needle pines") and the hard pines ("two-needle pines"). If arabinose were not found in the former, but were present in the latter, a chemical differentiation might be possible. *This hope was not realized.* All the pines examined yielded small amounts of the sugar.

The experiments were made (in each case) by hydrolyzing 25 grams of the air-dried (unextracted) pinewood with 1 liter of 0.01 *N* sulphuric acid at 100° for 4 hours. The suspension was neutralized with barium carbonate, heated, and filtered. The filtrate, which was always colored (and which, in the case of sugar pine, was quite dark), was evaporated to a small volume on the steam bath. It was then treated with a large excess of 95% ethanol to remove barium salts, centrifuged or filtered, treated with bone black, refiltered and evaporated to 10 ml. A 5-ml. (refiltered) aliquot was treated with an alcoholic *diphenylhydrazine acetate* solution (*5*). After standing several days, the solution (in every case) gave a crystalline deposit of arabinose diphenylhydrazone, showing the typical long prismatic needles, oriented into rosettes, which, after several recrystallizations, melted (on the Fischer block) at 197 to 201° (uncor., with decomposition), depending on the rate of heating. In the Thiele melting point bath, the decomposition point was 204° (cor.). None of these showed a markedly depressed melting point when mixed with an authentic sample of arabinose diphenylhydrazone (m. 201°). Quantitative determinations were not made, but the yields of arabinose obtained showed minimal values of several tenths of 1% (on the weight of the wood). The only other common sugar diphenylhydrazone which is insoluble under the conditions of the experiment is that of fucose. The fucose diphenylhydrazone melted at 198° but showed a very different crystal structure

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from that of the arabinose derivative. When mixed with arabinose diphenylhydrazone, the mixture, in every case, gave a very definite melting point depression. Salient data are given in the following table.

Sample used	*M.P. of diphenylhydrazine*	*Mixed M.P. (with A)*	*Mixed M.P. (with B)*
Sugar pine (soft pine)	197°	196°	191–192°
Idaho white pine (soft pine)	200°	199–200°	190°
Virginia pine (hard pine)	198–199°	197°	190°
Authentic sample of arabinose diphenylhydrazone (A)	201°	...	194°
Authentic sample of fucose diphenylhydrazone (B)	198°	194°	...

Van der Haar (*12*) gives the melting point of arabinose diphenylhydrazone as 204° with a comment that "this is not easily reached." One of his melting points is 199°. He gives the melting point of the fucose derivative as 197 to 198°.

The results given above were confirmed by paper partition chromatograms made by the method of Partridge (*13*). In the case of Idaho white pine and sugar pine hydrolyzates (0.01 *N* sulphuric acid), treated as previously described, these chromatograms showed the absence of fucose and the presence of arabinose and/or mannose. However, as neither hydrolyzate yielded mannose phenylhydrazone, the "sugar spot" must be ascribed to arabinose. Xylose, glucose, galactose, and rhamnose were also shown to be absent from both of these hydrolyzates.

Two typical commercial coniferous pulps were also subjected to the mild 0.01 *N* sulphuric acid hydrolysis. One of these was an unbleached spruce sulphite pulp and the other was an unbleached jack pine sulphate pulp. The hydrolyzate from the former yielded no trace of arabinose. Both the paper chromatogram and the diphenylhydrazine reagent gave negative results.

The kraft pulp hydrolyzate, however, yielded very small (undetermined) amounts of arabinose [diphenylhydrazone, m. 198° (uncor.)]. This was confirmed by the typical "arabinose spot" when paper partition chromatography was applied.

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Paper for Web Offset Printing

MILTON ZUCKER

The desirability of cooperation between the manufacturers of printing paper, printing ink, and press equipment is well indicated by the immediate success of high-speed magazine printing something over 12 years ago when the introduction of the new machine-coated paper and the new heat-set printing inks, together with new heaters, changed the entire face of the magazine printing field. Before, rotary web letterpress magazine printing was restricted to single colors at very low speeds on stocks of relatively low finish; after, high speed and color on smooth good finish stocks was the rule. The development of paper and ink has moved the process to where four-color work is being done at speeds in excess of 1000 f.p.m., and although much remains to be done in the improvement of quality and economy, the process is firmly established.

Offset, like the principal competitive processes—letterpress, gravure, and aniline—has certain advantages and disadvantages. But it has been handicapped, in comparison with other processes, by the fact that the development of fast four-color web offset printing has not kept pace with the development of letterpress and other processes.

When the underlying causes are examined, it is found that presses never have been a barrier. Web offset presses were running as fast as web letterpress machines when letterpress printing took off in the direction of higher speed and color work. Currently, there are some 160 users of web offset.

Ink was a barrier only a short time. Within a few years after the development of heat-set typographic inks, research found how these inks had to be made to give satisfactory lithographic properties.

Plates were a problem for a longer period. The type of offset plate in vogue 12 years ago was of uncertain life. It might last from 25,000 to 200,000 impressions; at the 15,000 impressions per hour demanded by high-speed production, a four-hour make-ready would ordinarily produce only two to four hours running time, depending on luck. Research, however, has removed this barrier so that, as of about

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two or three years ago, offset has multimetallic plates which give runs in the order of 1,000,000 or more impressions, comparable with letterpress.

The problem of setting type copy is still present, but it is a problem of economics rather than speed; type can be set, proved, and coordinated with the pictorial matter with little loss of time. However, phototypesetting is in the active pilot development stage and should provide economies for both offset and gravure.

The life of the dampers on a press is considered a problem by some advocates of web offset but the utilization of long-life plates on continuous runs indicates that the problem is not critical. One report indicates from five to ten times normal damper life on seven week runs with long life plates. This was on a sheet fed press, however.

The principal problems of offset printing remain—the pressman and the paper. Good offset printing requires pressmen who are really craftsmen, because good reproduction requires constant attention to the relationship between ink and water, plus the know-how that can only be acquired by experience. And in process work, the boss pressman must watch, in addition, the relationship between four sets of ink and water on two sides—16 variables, twice the number in letterpress. Experience indicates that really good pressmen can do the job, but there are no data on the economics of the problem, either in terms of labor cost or in terms of paper waste.

In the author's opinion, paper is the principal factor which is retarding the rapid development of web offset printing in the publication field. About two years ago, our research laboratory installed a four-color rotary web offset press capable of running up to 900 feet per minute, and equipped with heaters, so that the factors influencing the process could be pilot-proved. We have worked with various sorts of inks, rollers, blankets, plates, dampers, and papers on many different sorts of jobs including newspaper and magazine forms, labels, business forms, and catalog forms. Good printing has been done on all these jobs but not consistently on every paper.

In the field of uncoated papers, it was found that ordinary newsprint means trouble. Even though the inks in the fountain are of the same order of body as high-speed letterpress publication inks, they act on the paper with greater force than do the letterpress inks, partially because of the longer distribution system, partially because of the thinner films. Ordinary newsprint lints up on the blanket and appears in the printed matter in times ranging from a few hundred impressions for poor paper up to perhaps half a 36-inch roll for better quality paper. Some surface sizing appears necessary; 100% groundwood sheets have been run which gave no trouble.

Other uncoated sheets have been uniformly satisfactory. The ordinary offset papers, and various supercalendered papers, all run without trouble. Some paper is being run commercially, right now. But none of these sheets have the "snap" which seems to be required by the purchasers of the printing. In the laboratory, fairly good-looking results with certain sheets calendered to the point where they had a bright finish were obtained, and although the sheets would lack both smoothness and compressibility for letterpress printing, they took an offset impression well. But it had to be admitted, when the fact was pointed out by more experienced printing critics, that the reproduction lacked the smooth look obtained with coated paper.

Experience with coated papers has not been as successful. At low speeds (up to 400 or so feet per minute) most coated papers were satisfactory, except for a few which blistered in the heater. But at higher press speeds, no paper has been found which, we can say with confidence, is adequate.

The problem is "piling"—literally, a pile of material accumulates on the blanket to such a height that it begins to appear in the print, and if it accumulates for a sufficient time embossing of the blanket may result. Really bad papers pile on all four blankets. The problem appears to be one of picking by the water since the pile appears in the nonwork areas. The piling on better papers invariably occurs at the trailing edge of a solid or heavy tone, and examination of the pile indicates that it is composed largely of clay and ink. The author's analysis of the difficulty is that loose coating on top of the sheet, or coating loosened by the pull of the ink, is pushed to the trailing edge of the solid by the centrifugal force and mixes with the ink. Water at this point is attracted by the clay, and the result is a much heavier ink which eventually refuses to transfer and keeps accumulating.

Most papers that have been examined show slight evidences of piling in a few minutes (about 1000 impressions). This gets successively worse until at about 5000 to 10,000 impressions the piling is so bad that the blankets must be washed. This is true with both machine-coated letterpress papers and the best conversion coated papers specially designed for offset.

However, there are indications that it is possible to do much better. In one such test, two rolls of paper which were supposedly identical came from a mill. One showed the customary amount of piling, but the other showed substantially no piling in 15 minutes. The difference between the coating was difficult to find, but on subjecting them to a pick test on a Vandercook proving press with a 500-poise ink (using the method described by Berberich et. al., (*Tech. Assoc. Papers* **31**: 281 (1948)), the good sheet showed no pick, and the ordinary sheet showed a very slight pick, although either paper was strong enough to show no evidence of picking under any normal press conditions. A second promising sheet was supplied by one of the prominent printing paper concerns, and before the paper was made, the problem was discussed carefully with their technical representative. This sheet piled only moderately and might run for 30 to 45 min. without washup. A third promising sheet, giving results somewhat like the second, was supplied by yet another paper mill. There is hope for presumably improved samples from both mills, but since mill runs are required and these interfere with production, progress has been slow.

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Neutral Sulphite Semichemical Pulping of Aspen

Effect of Certain Buffering Agents

E. L. KELLER and J. N. McGOVERN

Neutral sulphite semichemical digestions of aspen (*Populus tremuloides*) were made at the Forest Products Laboratory in yields of 74.0 to 75.5% with sodium sulphite pulping liquors buffered to give spent liquor pH values in the range of 7.2 to 8.9 with (a) sodium bicarbonate, (b) sodium carbonate, (c) sodium hydroxide, and (d) sodium sulphide. The results of these digestions were compared with those from digestions with an unbuffered sodium sulphite liquor made from technical-grade chemical, giving a spent liquor pH value of 6.7 The results were as follows: (1) cooking time decreased with increased alkalinity in cooking. The reduction was approximately one-half in increasing the spent liquor pH values from 7.2 to 8.9. (2) Pulp strength was little affected by the kind or degree of buffer except for a tendency toward slightly higher tearing strength when sodium hydroxide and sodium sulphide were used. (3) The brightest pulps were obtained with no added buffer or with small amounts of buffering agent giving spent liquor pH values of 7.2 to 7.4. A considerably darker pulp was obtained in digestions buffered to a final pH value of 8.9 with sodium sulphide. (4) When fairly large amounts of sodium bicarbonate were used, a slightly higher pulp brightness was obtained by not relieving the excess digester pressure over that of the steam.

Semichemical pulping* with sodium sulphite liquor is generally conducted under conditions giving neutral or slightly alkaline spent liquors. This procedure has been considered necessary mostly to prevent corrosion of iron digesters and equipment and partly to give pulp of a desired quality. Since the spent liquors from pulping with sodium sulphite alone are slightly acid due to the formation or presence during pulping of organic acids like acetic and tannic acids, it has been customary to buffer the liquors to give the final neutrality or slight alkalinity. In common semichemical pulping practice, the buffer is sodium bicarbonate resulting from the manufacture at the pulp mill of the sodium sulphite by sulphiting of soda ash. Some mills have also operated on commercial sodium sulphite and used soda ash as the buffering agent.

Other low-cost soluble alkalies such as sodium hydroxide and sodium sulphide are also possible buffering agents. These two compounds have a more positive pulping action than the carbonates.

Although considerable practical information on sodium sulphite semichemical pulping under neutral or slightly alkaline conditions is available from mill operation and some data are found in the literature on semichemical pulping, as discussed subsequently, the subject does not appear to have been covered as completely as desirable with respect to the effect of buffering action on semichemical pulp quality. The purpose of the present report is to present additional information on the subject from the results of experiments on sodium sulphite semichemical pulping of aspen chips using four sodium salts as buffering agents. The experiments consisted specifically of semichemical digestions with sodium sulphite alone and buffered with the following sodium salts: (a) bicarbonate, (b) carbonate, (c) hydroxide, and (d) sulphide. The digestions were made with a separate impregnation stage in order to obtain as uniform pulping as possible, using liquors with slightly varying concentrations of sodium sulphite to give pulp yields near 75% and with widely varying concentrations of the buffering agents to show their effect. The bicarbonate buffered digestions were made with and without relieving the pressure in excess of that of steam at the pulping temperature.

The literature on this particular phase of semichemical pulping is not very extensive. In early unpublished experiments on sodium sulphite semichemical pulping at the Forest Products Laboratory (*8*, *9*) the effect of varying degrees of alkalinity in the cooking liquor on pulp yield and color was studied briefly. The wood used was jack pine (*Pinus banksiana*). The variation in alkalinity was obtained by using sodium hydroxide, sodium bicarbonate, sodium carbonate, or sodium bisulphite in the sodium sulphite cooking liquor. The amount of auxiliary chemicals was variable in the range of about 14 to 40% of the sodium sulphite. In comparison to sodium sulphite alone, the presence of sodium hydroxide accelerated the pulping, decreased the yield, and produced brown-colored pulps. The pulps made with the carbonates had the lightest color. Both jack pine and aspen sodium sulphite semichemical pulps made with sodium bicarbonate were, however, found to be lighter in color than those made with sodium carbonate. Sodium bicarbonate was also stated to be better for use in semichemical pulping than sodium bisulphite. In other experiments on jack pine the addition of carbon dioxide at the start of a digestion made with sodium sulphite and sodium bicarbonate was reported to give a higher cooking pressure and a lighter-colored pulp than those obtained with a digestion without the added carbon dioxide. Additional experiments (*9*) indicated that sodium bicarbonate may be looked on as a necessary cooking chemical because of its use to maintain slight alkalinity during pulping to avoid corrosion of steel digesters. The findings from the above experiments were summarized in a publication (*10*) as follows: "The quantity of bicarbonate must be sufficient to at least neutralize the organic acids produced. The bicarbonate may be replaced or supplemented

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* In semichemical pulping, wood chips are softened and partially delignified by cooking in pulping chemicals and the pulping is completed mechanically, usually in an attrition mill (*4*).

by sodium carbonate or even by sodium hydroxide, provided the darker color of the pulp is not objectionable and provided also that modified properties of the product are desirable." Bray and Eastwood (*2*) studied the effect of sodium bicarbonate in particular in sodium sulphite semichemical pulping. Their experiments were conducted with blackgum (*Nyssa sylvatica*) sawdust using varying proportions of sodium sulphite and sodium bicarbonate. Considerable corrosion was encountered in the steel bomb used for the experiments when little or no bicarbonate was present, whereas increasing the bicarbonate present checked corrosion but gave darker pulps. The use of sodium sulphite alone resulted in greater loss of cellulose. Phelps (*7*) suggested that the ratio of sodium sulphite to sodium bicarbonate calculated on the basis of sodium carbonate be 7 to 1 for hardwood semichemical pulps made in yields near 80% for use in paperboard. For hardwood semichemical pulps made in yields near 70% for bleaching to papermaking pulps, a ratio of 4 to 1 was suggested.

	Per cent
Lignin	19.3
Holocellulose	81.1
Alpha-cellulose on holocellulose	48.4
Cross and Bevan cellulose	66.0
Alpha-cellulose on Cross and Bevan cellulose	49.3
Pentosans	19.3
Solubility in:	
Alcohol benzene	2.8
Ether	0.6
One per cent sodium hydroxide	15.3
Hot water	3.0

The digestions were made in a stainless-steel, steam-jacketed, tumbing digester of 0.84-cubic-foot capacity. The equivalent of 6.5 pounds of moisture-free chips was used in each digestion. The digestions were conducted in three steps: (a) steaming, (b) impregnation, and (c) cooking.

(a) Steam was introduced as the top of the digester at such pressure that uncondensed steam began to blow from the bottom of the digester after 13 minutes. The steam pressure was then reduced by one-half,

Table I. Impregnation and Cooking Conditions for Aspen Semichemical Digestions with Several Buffering Agents

	Impregnation								Cooking						
	Liquor charged		Chemical consumed		Na_2O neutralized,		pH values		Time at 170° C.		Pressure,[b]	Spent liquor			Pulp yield,
Digestion number	Na_2SO_3, g. per l.	Buffer[a], g. per l.	Na_2SO_3, lb. per 100 lb. wood	Buffer,[c] lb. per 100 lb. wood	lb. per 100 lb. wood	Pressure,[a] p.s.i.	Start	End	hr.	min.	p.s.i.	Na_2SO_3, g. per l.	Buffer,[a] g. per l.	pH	lb. per 100 lb. wood
Series I: No added buffer. Digester not relieved															
580–82	53.9	0.5	14.9	1.7	1.7	19	9.2	7.2	2	15	118	11.5	−1.1	6.7	74.2
Series II: Sodium bicarbonate as buffer. Digester not relieved															
581–91	52.5	4.0	15.1	2.0	2.0	31	8.8	7.3	2	15	133	10.7	0.5	7.2	74.1
589–90	52.1	7.8	15.1	3.1	2.1	41	8.5	7.4	2	..	146	11.2	2.6	7.5	74.2
618 574–83	51.0	15.1	14.5	5.0	2.3	54	8.5	7.7	1	50	157	10.4	6.9	8.4	74.6
Series III: Sodium bicarbonate as buffer. Digester pressure limited to 110 p.s.i. by relief															
587–88	52.6	4.0	15.1	2.0	2.0	28	8.6	7.3	2	..	110	10.9	0	7.3	74.4
585–86	47.8	14.1	13.7	4.8	2.4	52	8.6	7.5	.	50	110	10.7	5.5	8.7	75.2
Series IV: Sodium carbonate as buffer. Digester not relieved															
594–95	51.2	3.8	14.9	2.0	2.1	23	10.1	7.4	2	10	119	10.3	0.4	7.2	74.4
592–93	52.4	15.8	15.2	5.6	3.0	23	10.2	8.7	1	10	112	11.6	7 4	8.9	74.2
Series V: Sodium hydroxide as buffer. Digester not relieved															
688	54.7	4.0	15.6	2.2	2.3	15	12.9	7.6	2	..	108	12.2	0	7.2	74.4
597–98	48.9	7.0	14.7	4.1	3.0	17	13.5	9.5	.	50	103	13.0	1.2	8.9	74.8
Series VI: Sodium sulphide as buffer. Digester not relieved															
634–43	59.2	[d]3.5	20.7	...	...	21	12.4	8.0	1	25	112	13.6[e]	...	7.4	75.6
619–20	41.6	[d]8.9	21.5	...	...	18	13.0	9.5	.	30	103	8.1[e]	...	8.9	75.0

[a] Saturated steam pressure corresponding to 120°C. is 14 p.s.i.
[b] Saturated steam pressure corresponding to 170°C. is 100 p.s.i.
[c] Calculated as sodium oxide.
[d] Includes 0.5 gram per liter sodium oxide titratable alkalinity introduced by the sodium sulphite.
[e] Titratable sulphide ion included, and figured as sodium sulphite.

The literature on full sodium sulphite pulping with and without auxiliary chemicals is not quite pertinent to the present discussion and is referred to elsewhere (*6*).

EXPERIMENTAL

The wood (shipment 2423) was reduced to standard $^5/_8$-in. chips and carefully hand-screened to remove knots, dirt, and oversize pieces. The chips were air-dried to 93% dryness to prevent decay during the experiments. The chemical composition and solubility of the chips were as follows:

and the steaming was continued until the total elapsed time was one-half hour. Reweighing a batch of chips so treated showed the moisture content had increased to 51.5%, equivalent to 0.83 gallon of water.

(b) Four gallons of cooking liquor were added to the digester. This liquor had a concentration of approximately 50 grams per liter of sodium sulphite (technical grade, analyzing 95% by iodine titration) plus the various concentrations of buffering agents (technical grade), as indicated in Table I. The charge was heated to 120°C. in 25 minutes and held at that temperature for one hour. Then 2.4 gallons of the

cooking liquor were withdrawn through a cooler. Indirect heating was used.

(c) The contents of the digester were then heated to 170°C. and held there until the sulphite content of the liquor had decreased to about 10 grams per liter. Indirect heating was used.

The methods used for analysis of the cooking and blowback liquors are given in the appendix.

After the digester was blown down and dumped, the cooked chips were reduced to fibers in an 8-in., single-rotating-disk attrition mill operated counterclockwise to give a rubbing action on the fibers. The pulp was washed by filling the screen box and allowing it to drain four times. The pulp was then pressed out and sampled for the yield determination. After storing the pulp in a moist state for a week, a portion of the material was put through an 8-cut flat screen and six color sheets were made up according to TAPPI method T 218 m-46, using distilled water. Brightness was read on a Hunter reflectometer and expressed as percentage of G. E. brightness.

Strength properties of the pulps were evaluated after processing in a standard beater according to TAPPI method T 200 m-45. Chemical and physical testing of the pulps was by standard TAPPI methods except for holocellulose (*1*).

DISCUSSION OF RESULTS

The various buffering agents affected to a greater or lesser extent the conditions of the impregnation and cooking steps and the properties of the pulps. The impregnation and pulping conditions under use of the several buffering agents are given in Table I, and the properties of the pulps are given in Table II. The data in these two tables are tabulated in six series according to type of buffering action, as indicated.

Impregnation

The impregnation liquors varied in pH values from 8.5 to 13.0 with kind and amount of buffering agent used; the amount was varied to give specified spent-liquor pH values. The impregnation liquor with no added buffering agent (Series I) had a higher pH value than those with sodium bicarbonate (series II and III). Some of this alkalinity may have been due to the use of technical-grade sodium sulphite. Haffner and Kobe (*3*) investigated the system sodium oxide: sulphur dioxide and found the pH value of equimolar solutions to be 8.

The liquors after impregnation had slightly alkaline pH values, although that with no added buffer (Series I) showed an appreciable titratable acidity, 2.3 grams per liter in terms of sodium oxide. Somewhat less sodium sulphide calculated as sodium oxide was needed than the others to give a slightly alkaline liquor after impregnation.

Table II. Properties of Aspen Semichemical Pulps Made with Several Buffering Agents

Digestion number	pH value of spent liquor	Pulp brightness, %	Pulp strength[a] Bursting strength, Pt. per lb. per ream	Tearing strength, g. per lb. per ream	Tensile strength, breaking length meters	Folding endurance, Schopper double folds	Freeness,[b] ml.	Pulp yield, lb. per 100 lb. wood	Chemical composition Lignin, %	Holocellulose, %	Alpha-cellulose, %	Total pentosans, %
Series I: No added buffer. Digester not relieved												
580–82	6.7	52.6	0.76	0.78	6500	175	670	74.2	9.9	83.8	62.5	17.1
Series II: Sodium bicarbonate as buffer. Digester not relieved												
581–91	7.2	53.2	0.76	0.82	6350	250	670	74.1	9.9	83.8	63.4	17.3
589–90	7.5	52.3	0.72	0.79	6300	175	670	74.2	10.0	82.5	62.7	17.3
618 574–83	8.4	48.8	0.76	0.85	6300	260	700	74.6	10.3	83.0	62.7	17.9
Series III: Sodium bicarbonate as buffer. Digester pressure limited to 110 p.s.i. by relief												
587–88	7.3	52.1	0.74	0.79	6300	160	710	74.4	10.4	82.0	62.7	17.4
585–86	8.7	43.5	0.70	0.88	6150	165	660	75.2	11.6	81.5	62.2	17.5
Series IV: Sodium carbonate as buffer. Digester not relieved												
594–95	7.2	52.2	0.78	0.78	6350	220	650	74.4	9.7	82.0	63.0	17.3
592–93	8.9	43.2	0.74	0.80	6000	220	650	74.2	10.9	82.4	63.7	17.7
Series V: Sodium hydroxide as buffer. Digester not relieved												
688	7.2	50.4	0.75	1.00	6100	175	700	74.4	10.3	84.6	65.1	17.3
597–98	8.9	46.3	0.74	0.90	6400	220	685	74.8	11.6	80.7	63.0	17.2
Series VI: Sodium sulphide as buffer. Digester not relieved												
632–43	7.4	50.9	0.71	1.05	5900	115	750	75.6	10.8	83.2	63.5	18.2
619–20	8.9	29.7	0.74	0.79	6150	190	575	75.0	12.2	81.5	62.9	17.2

[a] Average data from interpolated strength values for test sheets with a density of 0.70 gram per cubic centimeter. Strengths on 25 × 40–500 ream basis
[b] Schopper-Riegler freeness.

The amount of buffer neutralized, as defined in the appendix, increased with increase in buffer concentration (Table I and Fig. 1). With bicarbonate, this increase amounted to slightly less than 5 pounds of sodium oxide per ton of air-dry pulp (0.35 pound per 100 pounds of wood) when the initial concentration was increased from 4 to 15 grams of sodium oxide per liter (Series II). From an economic aspect, this increase is of minor important compared to the increase from 4 pounds to 53 pounds per ton of pulp in the amount of unneutralized buffer discarded at the end of the cooking period. A trend toward an increase in the amount of sodium oxide neutralized when more

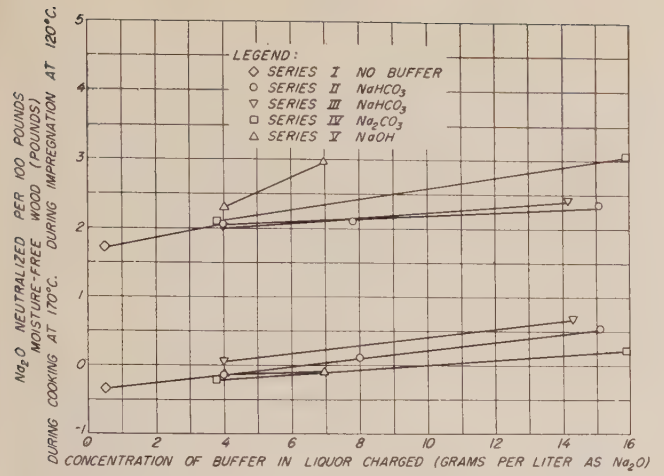
LEGEND:
SERIES I NO BUFFER
SERIES II NaHCO3
SERIES III NaHCO3
SERIES IV Na2CO3
SERIES V NaOH
Na2O NEUTRALIZED PER 100 POUNDS MOISTURE-FREE WOOD (POUNDS) DURING COOKING AT 170°C. DURING IMPREGNATION AT 120°C.
CONCENTRATION OF BUFFER IN LIQUOR CHARGED (GRAMS PER LITER AS Na2O)

Fig. 1. Neutralization of alkali during impregnation and cooking

active ions were substituted may also be observed in Fig. 1, with the amount being greatest with hydroxide and least with bicarbonate at equivalent concentrations of sodium oxide. The quantities neutralized show fair correlation with the pH of the liquor at the end of the impregnation stage (Fig. 2).

The concentration of sodium bicarbonate or sodium carbonate in the impregnation liquor did not affect the amount of sodium sulphite taken up by the chips. Previous experiments with sweetgum had indicated that a slightly increased sodium sulphite absorption resulted from increasing the concentration of sodium bicarbonate in the impregnation liquor (*5*). The sweetgum and aspen experiments were, however, conducted under different conditions, and the two species differ considerably in their absorptive action because of differences in density and chemical composition. It is possible that a high alkalinity in the impregnation liquor would aid the impregnation of dense, difficultly penetrated woods. In the present experiments with a wood of low density, like aspen, and under conditions of adequate impregnation time, the effect of alkalinity within the range applied on sodium sulphite absorption was not important.

In the experiments where the high concentration and pulping activity of the buffering agent made it necessary to reduce the sodium sulphite concentration to obtain the desired pulp yield, the absorption of sodium sulphite was directly proportional to its initial concentration in the impregnation liquor. This relation had also been observed in the experiments on sweetgum (*5*).

Earlier investigations at the Forest Products Laboratory had shown that the formation of wood acids was complete before the impregnation temperature of 120°C. was reached or after a short time at that temperature (*9, 10*). This was confirmed in these experiments by the pressure remaining constant after reaching 120°C.

Cooking

The pressure and time at the cooking temperature of 170°C. and the spent liquor pH values were affected by the kind and amount of buffering agent used (Table I). In the experiments with sodium bicarbonate an increase in its concentration resulted in increasingly higher pressures during the period at 170°C. due to the decomposition and formation of increasing amounts of carbon dioxide (and sodium carbonate) from the decomposition of the increased amounts of bicarbonate present. A steadily increasing pressure during the course of several of the digestions was also noted. The greatest increase of 12 p.s.i. from the start to the finish of the cooking was found in the digestion with no added buffer. This increase was probably due to acid hydrolysis of the wood to form carbon dioxide. The increase was very small with the higher concentrations of sodium bicarbonate, and there was no increase in pressure during cooking with sodium carbonate at the higher concentration and with sodium hydroxide and sodium sulphide.

When slightly alkaline spent liquors with pH values of 7.2 to 7.3 were obtained with sodium bicarbonate (both with and without pressure relief), sodium carbonate, or sodium hydroxide, the time of pulping was little affected by the nature of the buffer used (digestions 587–88, 581–91, 594–95, and 688, Table I). The digestion to the same final pH value with sodium sulphide was made, however, in about 35% less time, which indicated a definite pulping action by the small amount of sodium sulphide present. The time of pulping was decreased by one-half or more by operating under conditions to give a final pH value of 8.6 to 8.9 instead of 7.2 to 7.3, using sodium bicarbonate with pressure relief (with formation of sodium carbonate when carbon dioxide was removed), sodium carbonate, or sodium hydroxide (Nos. 585–86, 592–93, and 597–98, Table I). This accelerated pulping would be expected from the relative reaction rates well known for pulping under alkaline and neutral conditions. There was no great difference with the three agents. A still more accelerated pulping was obtained with sodium

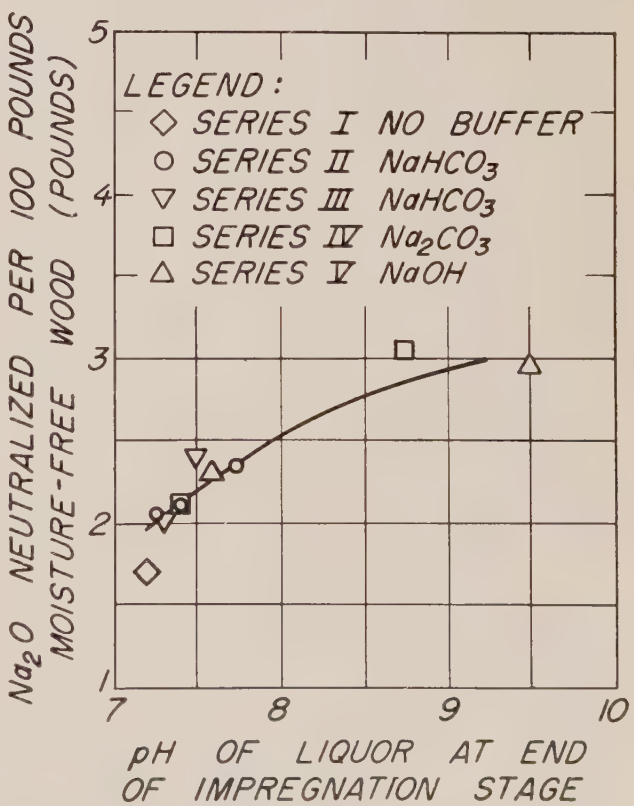
LEGEND:
SERIES I NO BUFFER
SERIES II NaHCO3
SERIES III NaHCO3
SERIES IV Na2CO3
SERIES V NaOH
Na2O NEUTRALIZED PER 100 POUNDS MOISTURE-FREE WOOD (POUNDS)
pH OF LIQUOR AT END OF IMPREGNATION STAGE

Fig. 2. Influence of pH on amount of alkali neutralized during impregnation stage

sulphide than with the others when pulping to a spent-liquor pH value of 8.8 (Nos. 619–20, Series VI, Table I). This digestion was the shortest of all the digestions which again indicated the active pulping effect of the sulphide.

The spent-liquor pH values of digestions made with sodium bicarbonate with no relief were slightly lower than those made with sodium bicarbonate with relief or with sodium carbonate, all on the same sodium oxide basis (series II, III, and IV, Table I).

Pulp Properties

Pulp brightness was influenced considerably by the kind and extent of buffering action. The brightest pulps were obtained when no buffer was used or when the conditions gave spent-liquor pH values of 7.2 to 7.5 (Nos. 580–82, 581–91, 589–90, 587–88, 594–95, 688, and 632–43, Table II). Under these conditions the pulps made with sodium hydroxide and sodium sulphide had only slightly lower brightness values than those made with the bicarbonate or carbonate. In the digestions with sodium bicarbonate without pressure relief, pulp brightness was not affected appreciably until a large excess of the buffering agent was present and the spent liquor was alkaline to a pH value of 8.4 (Nos. 574–83, 618, Table II). The pulps made under conditions of spent-liquor pH values of 8.7 to 8.9 were definitely darker than those made at 7.2 to 7.5 (Nos. 585–86, 592–93, 597–98, and 619–20, Table II). These included the pulp made with sodium bicarbonate with pressure relief to form sodium carbonate. Under these conditions, the pulp made with sodium hydroxide was, unexpectedly, slightly lighter than the others. The pulp made with sodium sulphide under the definitely alkaline conditions, on the other hand, was the darkest pulp of all. This pulp approached a sulphate pulp in appearance.

Pulp strength was apparently little affected by the buffering action within the range of the experiments (Table II). The pulps made with sodium hydroxide and sodium sulphide tended to have slightly higher tearing strengths than the others, as might be expected from the use of these alkaline reagents. The pulps made with sodium sulphide appeared to react differently in the test beater than the others. The pulp made with the lower pH value (Nos. 632–43) had a higher freeness, and that made with the higher pH value (Nos. 619–20) had a lower freeness value for a given sheet density than the others. If the pulps were compared on a basis of equal freeness values, the pulp made with sodium sulphide to the higher pH value of 8.8 (Nos. 619–20) would be appreciably weaker than the others.

The chemical composition of the pulps varied only slightly with kind and extent of buffering action. Compared at the same yield, the pulps made with sodium sulphide were slightly higher in lignin content and lower in holocellulose content than those made with no added buffer or with sodium bicarbonate without pressure relief. There was also a tendency for the pulps made with the more highly alkaline spent liquors to have higher lignin and lower holocellulose contents than those made with the slightly alkaline liquors. This tendency was illustrated by the trend toward an increase in the ratio of holocellulose to lignin removals with increase in alkalinity of the spent liquor (Fig. 3).

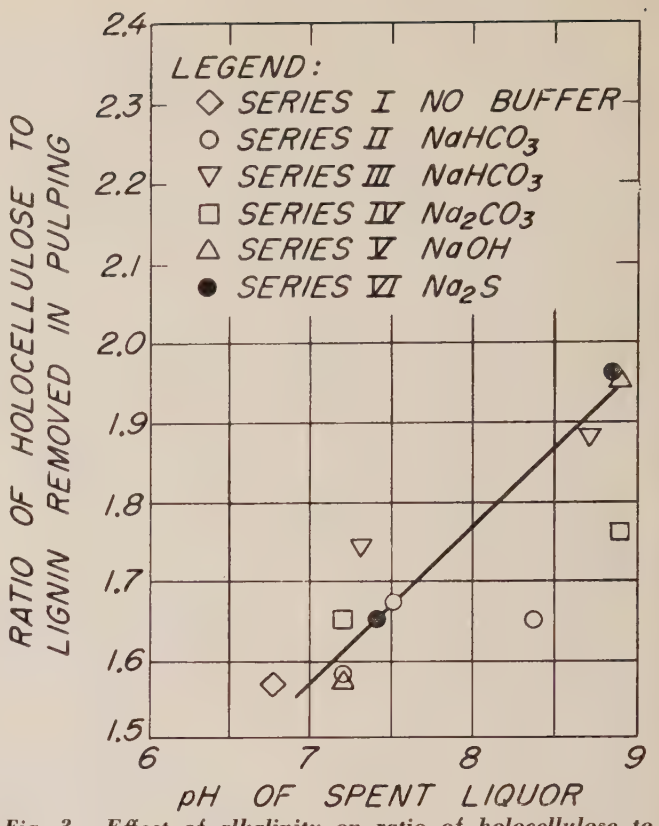

Fig. 3. Effect of alkalinity on ratio of holocellulose to lignin removed in pulping

APPENDIX

1. Cooking and blowback liquors were analyzed for sulphite content by pipetting a sample of the liquor into a flask containing an excess of iodine solution plus a few drops of standard acid, and backtitrating with thiosulphate. Alkali was determined by adding 5 ml. additional 0.1 normal standard acid to the contents of the flask after the thiosulphate titration, boiling under an air condenser to drive off carbon dioxide, cooling, adding an excess of standard sodium hydroxide with a drop of phenolphthalein, and completing the titration with acid. The sulphite-iodine reaction liberates an equivalent quantity of acid which must be allowed for in the calculation.

To reduce error due to reaction between the iodine and the organic matter present in the spent liquor samples, 50 ml. of water and 5 ml. of 1:1 hydrochloric acid were used to dilute the iodine before adding the sample to the flask. In determining sodium oxide in these liquors, the initial acid was reduced to 5 ml. of 0.1 normal, since tests showed the alkalinity determination was not influenced by the sulphite error.

2. The quantities and concentrations of the different agents used are given in this report as grams per liter of sodium oxide or as pounds of sodium oxide per 100 pounds of moisture-free wood. These figures can be converted to their sodium carbonate equivalent by multiplying by 1.71.

3. A distinction is made in this report between the amount of alkali expended in the digestions, as represented by the quantity not recovered when the liquor was blown back following the impregnation step, and the amount actually neutralized by the acidic mate-

rials from the wood. The first figure includes the unneutralized alkali remaining in the digester. The amount actually reacted with the wood, as calculated from the amount of titratable alkali (1) in the liquor charged, (2) in the liquor remaining in the digester after the blowback, and (3) in the spent liquor, is referred to as the "neutralized" alkali. This term also includes whatever chemical may be held on the wood structure by adsorptive forces.

4. The pH values of the various liquors were determined on liquors at approximately room temperature. It was not always possible to withdraw samples of blowback and spent liquors without loss of dissolved gas by foaming. The pH values given were determined shortly after the end of the digestion by a glass electrode.

5. Since the analytical method used did not distinguish between the reducing power of the sulphite and sulphide ions, the data on chemicals consumed in the sodium sulphide digestions are not available in Table I. In preparing the cooking liquor, the sodium sulphite and sodium sulphide were dissolved separately and added in the proper proportions just before charging to the digester.

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The Use of Statistical Methods in Determining Product Specifications

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The custom of applying upper and lower limits to measurements on manufactured products was adopted about 1870. The growth of specification writing began about 1900. Statistical methods are now being used to design specifications to meet today's need for better, rather than more, specifications.

Statistical methods minimize the amount of prior information needed to set reasonable specifications. They make it possible to determine the likelihood that new specification limits may be met. They may be used to justify changing specifications if more uniform quality has an economic advantage or if use requirements will permit relaxation in production controls.

Statistical studies assist the inexperienced and substantiate the judgment of the initiated by providing an objective means for determining realistic specifications. They replace subjective methods which may result in the all too common necessity for sorting, regrading, blending, reworking, or scrapping nonconforming product. Other penalties for arbitrary specifications may be the destruction of morale by the futility of efforts to meet impossible requirements or the carelessness bred in workers when very wide specifications cause them to lose incentive for superior workmanship.

The Shewhart control chart, increasingly used for process control in the paper industry, is the simple tool used in the specification review described in this article. Its value depends on the fact that the calculated control chart limits may be looked upon as the "natural" specifications of the process. A number of references are given to the method of calculating control chart limits and to the use of control charts in the paper industry.

An example is given of how new specifications are set and old specifications reviewed in an organization manufacturing chemicals for finishing of paper. The technique described may be applied equally well to the determination of specifications for paper. The nature of the statistical information used and the mechanics of carrying out the review and determining the specifications are described in detail.

It is of considerable value, in discussing specifications with operating or sales personnel, with technical service representatives or customers, to have measured the potentialities of the manufacturing process by means of the control chart. Misunderstandings may be removed and the parties concerned may be prevented from entering into agreements which it will be a continuing burden to fulfill. Not a little part of the benefit of the wide understanding of the relation of control limits and specifications is the feeling of order developed within an organization and even in the relationship between buyer and seller. It is believed that the statistical approach to determining specifications will thus make a worth-while contribution to both the internal and external functioning of a manufacturing organization.

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It may have been as much as 10,000 years ago that one piece of material first was fitted roughly to another and the idea of measurement became inevitable. However, it was not until modern times, about 1870, that the custom was adopted of applying upper and lower limits to measurements on manufactured products. The notion of using statistical methods to determine how best to design specifications is almost as new as atomic fission.

The growth of specification writing began about 1900, three decades before introduction of the control chart by Dr. Walter A. Shewhart (*1*), of the Bell Laboratories, made practical the wide use of statistical techniques by industry. Today, the need is not so much for more specifications as for better ones. This paper discusses (1) how prior information necessary for setting reasonable specifications may be minimized; (2) how specifications for a given manufacturing process may be determined which will have a predetermined probability of being met; and (3) how it is possible to determine the risk of failing to meet close specifications and, on the other hand, justify the narrowing of specifications if more uniform quality has an economic advantage.

THE NATURE OF SPECIFICATIONS

It is not to be implied that test data and past production results have not been used heretofore in determining specifications. Experience and judgment, without the aid of statistical analyses, have often provided bases for specifications that were entirely satisfactory and reasonable. It is the purpose of statistical studies to assist the inexperienced and to substantiate the judgment of the initiated. The first data coming from a production run may be used to predict the nature of all subsequent manufacture, or prove its unpredictability. Instead of relying on the average of past results or their extreme values, definite intervals within which any percentage of future production will fall may be calculated. Thus, values may be arrived at mathematically which represent the natural specifications of the process.

Exception may be taken only to specifications set arbitrarily without reference to a customer's actual requirements or on the basis of long-range guesses on market requirements. Such specifications are bad because they are not related to reality and disregard the ability of the production process to meet the standard set. Misuse of production statistics, likewise, may not be tolerated because of the economic penalty of making scrap. Even worse may be destruction of morale caused by futility of efforts to meet an impossible specification or the carelessness bred in workers when very wide specifications seem to make superior workmanship unnecessary.

A customer's actual requirements may not always be obvious, even to the customer. There is an understandable tendency to overspecify as a means of protection against shipments of marginal quality. Sometimes a fundamental study of raw material properties is necessary to bring out what can be used satisfactorily by a customer. This is an area in which statistical methods may be used to great advantage in buyer-seller relationships.

If the ability of the production process to meet the specifications is disregarded due to lack of information on the statistical nature of production or because of sales department or customer pressure, the result may be excessive production costs. This may come about through the all too common necessity for sorting, regrading, blending, re-working, or scrapping nonconforming product. For example, rigorous ordnance requirements during the war often required careful classification of material and scrapping of immense quantities of rejects.

In the instance of the ordnance requirements the cost of production was secondary to the requirement for arms of superlative quality. Consider, however, the saving in time and man power which could have been obtained had all manufacturing processes been capable of meeting the specifications! Under ordinary conditions, it may be possible to change either the process or the specifications. It is essential to profitable operation to know which course should be taken. Changing the process is a technical problem. Determining whether it is necessary to change the process to meet the specifications is a statistical problem. The actual changing of the specifications may be handled most adequately through a statistical approach.

The control chart is a handy tool in the setting of specifications because the calculated control limits used on it may be looked upon as the natural specifications of a process.

It should be pointed out, although fuller discussion is beyond the scope of this paper, that good limits by themselves do not make good specifications unless (1) the characteristic being tested is an important one to control for the purpose intended; and (2) the method of measuring the characteristic actually correlates with the thing it is being used to measure. Close study of the reason for the specification and its function is recommended before applying the control chart method for calculating limits.

The control chart is a means of determining whether the greatest possible uniformity is being achieved in a manufacturing process. If the control chart indicates uniformity (or control) yet the results exceed specifications, the technical problems of an improved process must be tackled. If the process is not uniform (or uncontrolled) technology is called upon again to achieve uniformity. Specifications should not be altered nor the process be changed fundamentally until the chart shows that the very best results are being obtained from the existing process. If all attempts to control the process fail or if process improvement is technologically impossible or economically unfeasible, consideration should then be given to changing the specification. Under these circumstances, changing the specifications becomes a matter of company policy which may often involve convincing the customer of the justification of this step.

Whether it is for the purpose of setting up a new specification or reviewing an old one, the statistical procedure is the same. The first step is to determine what the process is capable of doing and whether it is performing within that capability consistently. This is done by means of a control chart study.

THE NATURAL SPECIFICATIONS OF A PROCESS

How to set up a control chart and how to use it for process control have been covered well during the past three or four years in papers given at various national and sectional meetings of the Technical Association of the Pulp and Paper Industry. Interested persons are referred to the standards published by the

American Standards Association (*2*), and the American Society for Testing Materials (*3*), and to a variety of articles in the trade literature by Catlin (*4*), Knoll (*5*), Grant, Mason, and Donnelly (*6*), Bicking (*7, 8*), and other writers on the control chart and related techniques listed in the bibliography.

Information for specification design comes from the finished control chart kept on a process long enough to determine whether the process is truly uniform. The control chart is a simple means for determining with a minimum amount of data, often from as few as 25 measurements from a process, the limits within which future results will fall if the process is truly uniform and if there is no change in processing conditions. It indicates whether the uniform or stable condition called "control" exists and if not, it assists in locating causes of unusual variation. The control limits may be calculated to include a desired percentage of all likely results. Limits which include 95% of production, unless assignable causes for differences occur, are in common use in the paper and related industries. It is the purpose of technical control in a mill to prevent occurrence of the assignable causes of variation. In this paper, it is assumed that it has been demonstrated that the process for which a specification is desired is in control or may be brought into satisfactory control. It is of distinct advantage that the control chart techniques used to govern routine manufacturing operations automatically provide the data and information for setting up formal specification.

Control chart limits may be set to include any desired percentage of the usual range within which test results will fall. Therefore specifications likewise could be set at these calculated distances from the process average to include 65, 95, 99.7% or any other percentage of expected results. On the other hand, if specifications are determined by market requirements or the limitations of a certain customer's process, the percentage of the total expected spread covered by the specification band may be calculated. Thus it is possible to determine, in instances in which the specifications are narrower than the normal process control limits, just how much of the product is likely to have to be rejected by sorting. It follows then that an economic balance can be obtained between the cost of producing a more uniform product and the cost of sorting and rejecting off-grade material. In other words, it becomes possible to determine economically reasonable new specifications or to determine how existing specifications may be modified to be reasonable, realistic, and economical.

It is important to have information at hand on the precision of the testing methods because control limits include both the actual variation in the product and the apparent variation due to the nonuniformity of the test. Repetitive measurements made on a single sample of product will differ in some instances enough to cover the whole range of measurements obtained on different samples. It is, therefore, impossible to control the uniformity of a product more closely than the tests can be controlled. Intelligent use can be made of process information in setting specifications only when this kind of information on test precision is at hand.

One question which comes up in the discussion of specifications concerns the matter of retesting when the test variation is a fairly large part of the total variation encountered. If a retesting procedure is used, a considerable number of batches rejected on the basis of the first test may be acceptable on the basis of the subsequent information. A definite procedure for resampling and retesting must be included in the acceptance procedure used in connection with the calculated limits if there is to be no misunderstanding on this point.

EXAMPLE OF STATISTICALLY DETERMINED SPECIFICATIONS

How new specifications are set and old specifications are reviewed can be discussed best by a specific example. In an organization manufacturing material for finishing paper, control charts were kept over a period of two years on all the quality measurements on products made by four different plants. Past data on old products made in quantity were used to set up the original control limits. Usually standard limits were adopted after 100 measurements (separated into 25 groups of four) were accumulated. However, control limits for new products were calculated when as few as a dozen measurements had been obtained (using moving ranges of consecutive values) and revised twice later when 25 and 100 measurements were reached. Separate control charts were kept for each product and for each unit of equipment making that product. Since the usual number of units at one plant was only two or three and the variety of products made during a month relatively small, this did not involve as large a number of charts as might be expected. A clerk was able to keep the charts posted regularly from the laboratory reports in less than an hour per day. Over the period of their use, technical action based on control chart study resulted in bringing all of the products inside control limits at satisfactory quality levels with much improved uniformity. Graphic evidence of this improvement led to the conclusion that it was time for thorough review of all specifications to obtain the sales advantage of improved quality and to fill gaps in the specification structure.

Accordingly the complete control chart record was assembled from the four plants. The results were summarized on a printed form designed for the purpose. Each summary sheet contained space for the following general information:

Name of product
Plant name
Equipment unit designation
Period covered by data
Number of batches involved
Probability associated with limits used
Size of subgroup used to obtain limits
Type of limits used (for averages or individual measurements)
Remarks
By whom data studied
Date of study

Space was provided for tabulating data on the following specifications, some but not all of which applied to every product:

Softening point, °C.
Bath temperature, °C.
Acid number
Color, U.S.R.G.
Viscosity, G-H
Solvent
Solids, %
Refractive index
Haze, Hercules standards
Compatibility

For each of the specifications applying to a given product, the following information was entered in the table:

Information required	*Example of typical data entered for color of product*	
Test precision	±1/2 grade, 99.7% probability basis	
Present specifications		
Maximum	K	U. S. Rosin Grade
Minimum	None	
Process average	WG-1	U. S. Rosin Grade
Process upper control limit	N-0	U. S. Rosin Grade
Process lower control limit	WW-2	U. S. Rosin Grade
Proposed specifications		
Maximum	M	U. S. Rosin Grade
Minimum	None	
Estimated per cent production outside proposals		
Groups of test	M = zero N = zero	
Individual tests	M = zero N = 2.4%	

Note: Maximum specification reduced one whole color grade.

It should be noted that though the color designation is in terms of letters, no difficulty was encountered since for purposes of control limit calculation numbers on a linear scale were substituted.

A table such as this was made for each plant and each unit of equipment in which the product was made. The process average and calculated control limits may have been different for each unit. However, changes in the specifications were made so that in no instance would any averages of subgroups of tests nor more than 5% of the individual test values fall outside of specifications. In the example given, none of the units were expected to have groups of tests averaging darker than color M or, as a matter of fact, any individual color tests darker than M. Actually the color specification could have been reduced to N (two grades lighter than the original K specification) without exceeding the limitation decided on. No group averages were expected to be darker than N and only 2.4% of the individual tests were expected to be darker than N. However, it was considered wise to bring the specification down a step at a time so the new upper color specification of M was adopted.

It may appear to be rather expensive to set limits which could cause rejection of as much as 5% of the product. The choice of the proper percentage always must be made with economic consequences in mind. In this instance, control of most product characteristics was within such narrow limits that only rarely would any individual tests at all fall outside of specifications acceptable to the trade. Even in the few instances where it was possible for 5% of individual batches to be outside specifications, the penalty of down-grading was not great. For example, slightly darker than normal resin colors were acceptable for a great many uses.

Another example of the data assembled for choice of specification limits involves numerical values rather than letter grades. It is illustrative of by far the greatest number of applications of the technique.

Information required	*Example of typical data entered for softening point of product*
Test precision	±3.0°C., 99.7% probability basis
Present specifications	
Maximum	141.0°C.
Minimum	124.0°C.
Process average	132.6°C.
Process upper control limit	138.1°C.
Process lower control limit	127.1°C.
Proposed specifications	
Maximum	140.0°C.
Minimum	125.0°C.
Estimated per cent production outside proposals	
Groups of tests	Zero
Individual tests	Zero

Note: Range of specifications decreased 2.0°C.

Although the examples used have involved a chemical product, the techniques described may be transferred wholly to the setting up of specifications for paper.

SYSTEM FOR SPECIFICATION REVIEW

The above specification survey was authorized by the operating manager of the company department which managed the four plants involved. The plan for the survey was laid by the company quality control engineer in collaboration with a representative of the central research laboratory staff in the division concerned with research and development problems for the operating department. The quality data from each of the plants was supplied by the plant staff man responsible for following product quality by means of the control chart. The data available from the plants included a tabulation of all quality results for two years broken down, as mentioned, by product and unit of equipment. It also included the complete control chart record of production. From these data the process average and process upper and lower control limits were tabulated.

Present specification data were obtained from the department specification notebook. Data on test precisions were supplied by the head of the central research laboratory group responsible for the development and control of analytical and testing methods.

From these data, the quality control engineer determined and entered in the table changes in the specifications which could be made under the restriction that no test group averages and no more than 5% of individual tests should exceed the proposed specifications. Notation was made if a change was suggested whether it involved narrowing of the specifications, addition of a missing specification, an entirely new set of specifications, or the widening of existing specifications. If it were possible, as in the case of the color example, to improve the specification by more than one grade, or unit, the estimated percentage of groups and individual values outside proposals were given step by step.

Several copies of this tabulation were prepared for a meeting in the office of the manager of operations. Attending this meeting were the operating manager, the member of his staff appointed as liaison with the quality control group, the company quality control engineer, the research group representative

and analytical group representative who had participated in planning the survey, the department sales manager and assistant sales manager, and the department director of technical service.

Available for this committee were the tabulated survey sheets, the control chart data sheets from all the plants, and the control charts themselves. The products were considered one at a time and all points of view heard on any suggested additions or changes to the specifications. This part of the job was painstaking and time consuming but was felt to be well worth while by all participating. The result was a far better appreciation of the meaning of the specifications, the actual quality of departmental production, and the relation of manufacturing capability to customer requirements than had existed at any time previously. It was felt desirable by the committee to add a man to the staff of the operating manager whose responsibility should be a continuing study of the relationship between customers' technical requirements and the plants' ability to meet those requirements consistently. The most positive angle which this work was to take was coordinating the departments' production and specifications most closely with the changing and developing needs of the market.

Copies of the committee's recommendations were then sent to each of the plants for review and suggestions. The general attitudes of the plants toward the changes were good. Those plants which had been having most trouble with product quality level or uniformity agreed that their results could be improved and the revised specifications met consistently.

When all comments were in, the specification notebooks were revised in accordance with the suggestions of the committee and redistributed. An arrangement was made for the committee to meet at least annually for thorough review of specification on the basis of most recent control chart results. In the meantime the new member of the operating manager's staff has been assigned the duty of preparing tentative specifications for new products or for product modifications which customer requirements may make imperative on short notice.

CONCLUSIONS

The type of specification review described was possible with the expenditure of relatively little time and energy because a control chart record of production had been kept for a sufficient length of time to develop confidence in the capabilities of the process. This kind of confidence in the process must be gained before specifications may be determined by any means. Arriving at a sufficient degree of confidence in the process will always require some testing and measurement. Unless the measurements are objective, the specifications cannot be realistic except by chance.

Since the confidence which may be put in very few measurements may be evaluated only statistically, the control chart approach becomes very valuable for setting new specifications. Even for older, well-established processes, however, control chart study will almost always bring new facts to light. It is not necessary to spend two years making a preliminary study of the process. The first charts, based on recent experience, will tell the story of control, or its lack, and the significance of control limits with relation to old or proposed specifications.

It will be of very considerable value in discussing specifications with sales personnel, technical service representatives, and customers, to have measured the process potentialities by means of the control chart. Misunderstandings may be removed and the parties concerned may be prevented from entering into agreements which it will be a continuing burden to fulfill. Not a little part of the benefit of a wide understanding of the significance of process limits and specifications is the feeling of order developed within an organization and even in the relationship between buyer and seller. It is believed that the statistical approach to determining specifications will thus make a worthwhile contribution to both the internal and external functioning of a manufacturing organization.

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Conversion of Purified Guar Mannogalactan Mucilage for Tub-Sized Adhesive

ARTHUR J. HAUG

Conversions of the purified guar mucilage by oxidation in the presence of borax with sodium hydroxide at pH 11 produce adhesives which are useful as tub-sizing materials. Only a small amount of oxidant (approximately 5%) is necessary to degrade the guar polymer to produce a product of suitable viscosity. The folding endurance and bursting strength of a rag sheet were increased up to 187 and 46%, respectively.

Although the guar plant was introduced into this country by the United States Department of Agriculture in 1903 (*1*), only in the last few years has it become the object of special interest. Because the war prevented locust bean flour importations, investigations were carried out by The Institute of Paper Chemistry to find a satisfactory domestic source of mannogalactan. The mannogalactan from the guar seed was shown to have suitable properties for use in the paper industry. The southwestern United States offered the most satisfactory agronomical environment for the plant and successful plantings and harvestings have been made there. The cooperative efforts of the United States Department of Agriculture, The University of Arizona, General Mills, Inc., and The Institute of Paper Chemistry in the development of this guar program have been reported by Rowland (*2*).

Among the interesting characteristics of guar mucilage may be mentioned the thick viscous sols that result from dispersion of the material in either hot or cold water. These extremely viscous sols do not form a gel on standing. Guar flour has from four to eight times the thickening power of starch (*1*). The high viscosity of the sol is broken by treatment with acids, oxidizing agents and, to some extent, alkalies. The mucilage may be recovered from an aqueous dispersion by precipitation with alcohols or acetone.

One of the most interesting characteristics of the mucilages is the thick gel that forms when a borax solution is added to an aqueous dispersion or sol. This gel is dry to the touch and does not stick to glass, paper, skin, etc. If the dry mannogalactan flour is added to a borax solution, an insoluble borax-mucilage gel forms and a coarse suspension of the insoluble particles results. The formation of a borax-mucilage gel is known, but the nature of this complex formation is not understood. The gel or suspension of gel particles can be destroyed by lowering the pH to just under 7. In a pure system the gel will remain stable for long periods of time but the addition of traces of other electrolytes causes rapid syneresis.

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To the papermaker the mannogalactans offer many advantages. On a commercial scale, the chief use of the mucilages or gums* is as a beater size and many improvements in products have been effected with quantities as low as 0.25% on the weight of the fiber. Savings in power and time have been made possible by incorporation of the mucilage in place of the mechanical work done on the stock. The expression "pouring hydration from a barrel" is a result of this property. Rowland (*2*) has reported the many papermaking benefits of guar mucilage.

Use is made of the insoluble complex formed with borax by Smith (*3*) in the manufacture of a wet-strength paper. After the locust mucilage is added to the beater, the fabricated paper is treated with a borax solution to insolubilize the mucilage.

In addition to the use of mannogalactans as a beater size in the paper industry, they have distinct advantages as adhesives for tub sizing. In order to produce a product from guar mucilage which is suitable as a tub-sizing adhesive, it is necessary to degrade the polymer. Swanson (*4*) has taken advantage of the insoluble borax-mucilage gel phenomenon in converting the mannogalactans with various oxidants. There has been a patent application (*5*) made on the process of converting guar mucilage in the presence of borax by the use of sodium hypochlorite.

The mannogalactan literature has been covered by March (*6*), Yirak (*7*), and Haug (*8*). The purification and characterization of the mucilage used in this work will be discussed in a later publication.

Conversion of commercial guar mucilage in the presence of borax by sodium hypochlorite for tub-size adhesives has been carried out by Swanson (*5, 9*). However, a similar conversion of a purified guar mucilage under controlled conditions for this purpose has never been reported.

EXPERIMENTAL

Conversion of Mucilage

Four experimental conversions were made according to the conditions given in Table I.

Table I. Conditions Used in the Oxidations of Purified Mucilages for Tub-Size Adhesives

pH	11.0 ± 0.4
Temperature, °C	40 ± 1
Gum, g. (oven-dry)	65.0
Gum concn., % (by weight)	7.25
Borax, g.	19.5

* The term "gum" is used interchangeably in industry with mucilage, although "gum" is strictly reserved for pathological and mucilage for physiological plant components. Both terms will be used in this paper.

Experiment	Product	Chlorine, g	Chlorine on oven-dry gum, %
L	L-1	3.25	5.0
M	M-1	6.50	10.0
N	N-1	9.75	15.0
O	O-1	13.00	20.0

The procedure was as follows: The gum was slowly added to the aqueous borax solution, followed by the sodium hypochlorite. Each reaction was allowed to proceed until 99% of the oxidant was consumed. The products were filtered on large fritted-glass funnels and allowed to air-dry for at least 48 hours. The material was ground in a Wiley mill and screened through a 40-mesh screen. Moisture and ash determinations were made on each sample and the yield of converted product calculated. The results are presented in Table II.

Table II. Yield and Ash Content of Products L-1, M-1, N-1, and O-1

Product	Ash, %[a]	Yield, %[b]
L-1	13.6	86.6
M-1	17.6	86.2
N-1	18.8	80.8
O-1	19.9	75.6

[a] Expressed on oven-dry basis.
[b] Expressed on oven-dry ash-free basis.

Preparation of Products for Tub Sizing

A so-called "cooking" procedure is required prior to the sizing operation. On addition of the material to water, a suspension results and addition of an acid is necessary to neutralize the borax. A heating period follows to insure complete dispersion of the mucilage. The following procedure was employed:

1. Add 525 ml. of water to a tared liter beaker.
2. Add 47 grams (on oven-dry basis) of product.
3. While stirring, add 3 *N* HCl until the contents are slightly acid (determined by means of alk-acid paper).
4. Heat with direct steam to 80°C. and maintain at this temperature for 15 to 20 minutes.
5. Add water to give a 5% concentration of adhesive, by weight.
6. Stir for 5 minutes.
7. Adjust temperature to 60°C. by means of a steam bath.
8. Determine the viscosity at 60°C. by means of a 25-ml. pipet. The time of flow between the mark and the end of the constriction of the bulb was measured.
9. Allow the temperature to fall to 57°C. and then run sizing operation.

Tub-Size Operation

Tub sizes were made with the products at 5, 3, and 1% concentrations to evaluate them as adhesives. The concentrations studied are comparable with those sometimes used commercially in starch tub sizing. A lightly calendered 100% rag sheet containing a small amount of rosin and starch size was used in all the sizing tests.

The sizing apparatus consisted essentially of a tub, press or wringer rolls, and a reel. The tub was a flat pan with a capacity of 800 to 1000 ml. The paper was led through the adhesive by two submerged rolls at opposite ends of the pan. The rubber press rolls were approximately 1.75 inches in diameter and a constant pressure at the nip was used in each operation. The bottom press roll was driven at a constant rate and the paper was sized at the rate of 16 ft. per min. The reel was wound by hand and was constructed so that the paper could be slipped from the core immediately.

About 25 feet of paper were sized in each experiment. After the paper was threaded through the apparatus, the sizing solution at 57°C. was poured into the tub and the press rolls were started simultaneously. The equilibrium temperature in the tub was 55°C. The sized paper was air dried in festoon fashion and then conditioned in the humidity room at 50% relative humidity and 73°F. for at least 24 hours prior to testing.

The sizing solution was recovered from the tub and diluted accurately to 3% concentration. By means of a steam bath, the temperature was raised to 60°C. and the viscosity determined as described in the previous section. The sizing operation was then repeated as outlined above. The same procedure was followed at 1% concentration.

Determination of the Amount of Adhesive Retained by Paper in the Sizing Operation

The amount of converted mucilage retained by the paper was determined in the following manner. The weight of approximately 25 feet of unsized paper was determined. On this paper a length of 63.75 inches was measured from one end and conspicuously marked. The average weight of the marked portion of the unsized sheet was 17.0 grams (average of 12 determinations). This measured length was threaded through the apparatus at the start of a run. After the paper had been sized and wound on the reel, this marked length was removed and the remaining evenly sized paper was weighed immediately. The average weight of the marked length (17.0 grams) was subtracted from the original weight of the unsized paper.

Table III. Relative Viscosity and Retention of Products L-1, M-1, N-1, and O-1 in Tub-Sizing Operations

Product	Concn., %	Relative viscosity	Product retention by paper in operation, %
L-1	5	5.68	1.56
	3	2.24	0.89
	1	1.17	0.30
M-1	5	1.57	1.41
	3	1.25	0.86
	1	1.05	0.30
N-1	5	1.25	1.30
	3	1.13	0.80
	1	1.03	0.29
O-1	5	1.17	1.38
	3	1.09	0.86
	1	1.02	0.27

The difference in the weights of the sized and unsized paper gave the total amount of the sizing solution that had been picked up. Since the concentration of the sizing agent was known, the weight and percentage of the converted mucilage retained by the paper were calculated. The results obtained in this manner are presented in Table III, together with the relative viscosity of the gum sizing solutions at the various concentrations.

Paper Testing Results

Ten determinations were made on each test and the averages of the results are presented in Table IV.

Table IV. Paper Testing Results

Paper Tub Sized with Converted Mucilage Products

Product	Concn., %	Basis weight, (17 × 22/-500), lb.	Bursting strength		M.I.T. fold		Gurley porosity, sec. per 100 cc.	Elmendorf tear, g./sheet		Tear factor		Schopper tensile, lb./inch	
			Points	Pt. per 100 lb.	In	Across		In	Across	In	Across	In	Across
	...	19.0	30.0	158	174	47	160[a]	94	102	4.95	5.37	25.8	12.9
L-1	5.0	19.3	44.5	231	519	129	224	86	92	4.46	4.77	32.0	16.7[a]
L-1	3.0	18.9	40.8	216	428	95	154	86	99	4.55	5.24	30.4	14.9
L-1	1.0	19.1	36.9	193	244	72	141	88	100	4.61	5.24	24.3	13.8
M-1	5.0	19.4	40.7	210	392[a]	88	143	87	99	4.48	5.10	30.4	14.9[a]
M-1	3.0	19.0	37.8	199	307	80	133	89	100	4.68	5.26	27.4	14.4
M-1	1.0	18.9	34.8	184	280	66	129	93	97	4.92	5.13	26.1	13.7
N-1	5.0	19.4	37.0	191	264	70	135	89	94	4.59	4.85	25.6	14.2
N-1	3.0	19.3	36.3	188	240	68	133	94	100	4.87	5.18	27.3	13.5
N-1	1.0	19.1	34.6	181	243	59	127	94	104	4.92	5.45	25.6	13.1
O-1	5.0	19.5	36.4	187	293	71	129	90	99	4.62	5.08	25.3	14.2
O-1	3.0	19.5	35.4	182	230	66	129	94	98	4.82	5.03	25.6	13.6
O-1	1.0	19.4	32.8	169	260	58	129	92	105	4.74	5.41	26.7	13.3

[a]The average of nine determinations.

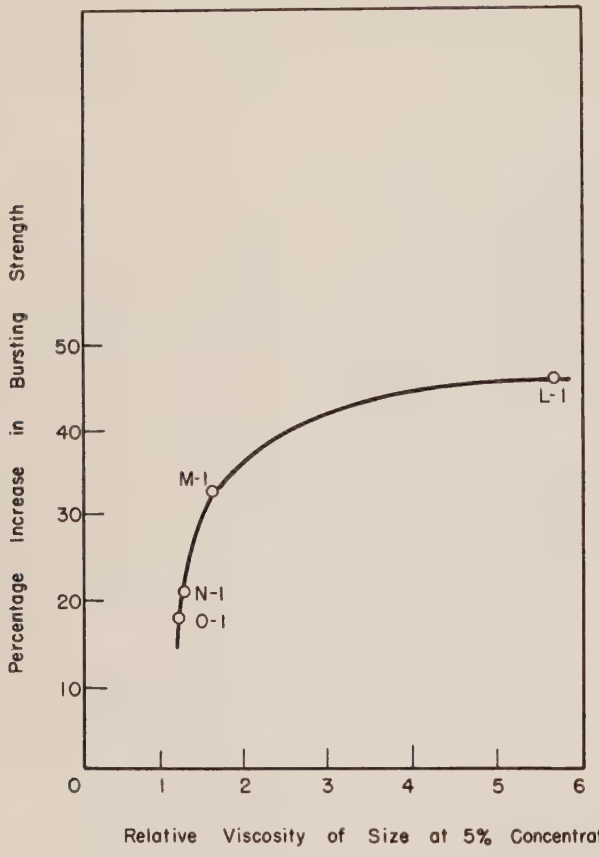

Fig. 1. Increase in bursting strength. Adhesive strength of converted products L-1, M-1, N-1, and O-1

DISCUSSION OF RESULTS

Conversion of the purified mucilage in the presence of borax produced a satisfactory adhesive for tub sizing. The product converted with 5% chlorine produced the greatest strength increments in the sized paper and it is probable that even less oxidant would have given products of still greater adhesive strength. In order to obtain products suitable for tub sizing from the commercial mucilage, Swanson (*9*) used 12 to 14% chlorine. However, unpublished work showed that the greater part of the oxidant was consumed by impurities present in the commercial gum rather than by the conversion of the gum itself.

The data obtained on the bursting strength and folding endurance of the sized paper, as shown in Table IV, were used to obtain the percentage increases of these tests over the blank values. These data are given in Table V and the values at 5% concentration are shown in Figs. 1 and 2.

From the figures it can be seen that the ultimate strength of the adhesive was not reached. However, significant strength increases were obtained with products L-1 and M-1 at 5 and 3% concentrations. Increases in the bursting strength up to 46% and in the folding endurance up to 198% in the machine direction and 174% in the across-machine direction were obtained. An increase in the amount of oxidant beyond 5% chlorine degraded the products substantially as measured by relative viscosity, and the strength increases gradually decreased.

The porosity of the sheet was not appreciably influenced by the sizing operation. The most viscous size (L-1 at 5% concentration) decreased the porosity whereas, in all other cases, the porosity was increased.

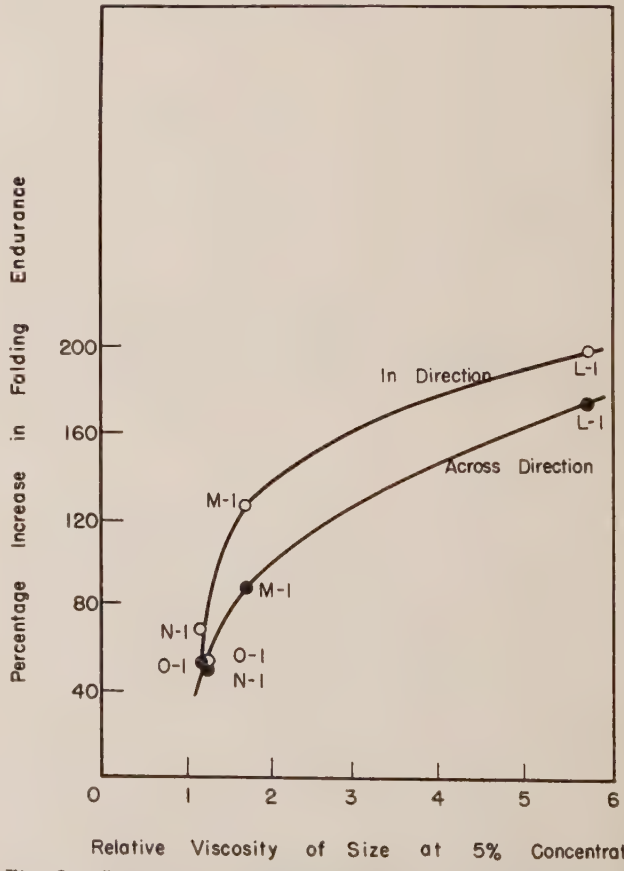

Fig. 2. Increase in folding endurance. Adhesive strength of converted products L-1, M-1, N-1, and O-1

Table V. Bursting Strength and Folding Endurance Increases in the Tub-Sized Paper

Product	Concn., %	Relative viscosity	Increase in burst, %	Increase in fold, % In	Across
L-1	5	5.68	46	198	174
	3	2.24	37	146	102
	1	1.17	22	40	53
M-1	5	1.57	33	125	87
	3	1.25	26	77	70
	1	1.05	17	61	41
N-1	5	1.25	21	52	49
	3	1.13	19	38	45
	1	1.03	15	40	26
O-1	5	1.17	18	68	51
	3	1.09	15	32	41
	1	1.02	7	49	23

It was not possible in this small-scale operation to determine whether the insoluble fraction present in all converted products (approximately 0.5%) was picked up by the paper or concentrated in the tub. However, the porosity was apparently unaffected by the flocculent material.

The tensile strength of the sized paper followed the trends shown by the bursting strength, although the effects were not as great. It was interesting to note that the tearing strength of the sheet did not decrease extensively on sizing while the bursting strength and folding endurance were greatly enhanced.

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Electric Cables for the Pulp and Paper Industry

FRANCIS V. CALVERT

To select the proper electrical cables to give the maximum in safe, economical distribution of large blocks of power, the following points should be considered: voltage levels, special conditions, developments in cables, and arrangement of feeders. Based on installed cost, a 4160-volt system is more economical than a 13,800-volt system for mill capacities up to about 10,000 k.v.a. In the range 10,000 to 20,000 they are comparable, above 20,000 the latter is the logical selection. Standard cables can be obtained for the various system voltages. Generally a radial distribution system is the most economical and affords sufficient system reliability for both low- and high-voltage feeders. The low-voltage system is most likely to require other variations. Special conditions which must be considered involve corrosion and moisture, heating of cables, voltage drop, short-circuit capacity of cables. Recommendations are given by the author for proper cable selection.

The pulp and paper industry is one of the major power consumers in this country and in Canada, for example, 50% of all power sold for industrial use in Canada is sold to the industry. Because the amount of power consumed is so great, economical distribution of that power with cables of the proper size and voltage rating is more important than in any other industry.

To select the proper electrical cables to give the maximum in safe economical distribution of the large blocks of power that must be transmitted, these points should be considered: (1) voltage levels for electrical distribution, (2) special conditions encountered and how to solve them, (3) new cable developments to increase reliability and lower power distribution costs, and (4) arrangement of feeders.

Studies have been made and the results published as to the economical distribution voltages for pulp and paper mills. It is the purpose in this paper to indicate what cables should be recommended to give the most reliable economical system. It must be remembered that the studies take into consideration the complete system costs including cable, switchgear, transformers, motors, etc. This, of course, is the only way to arrive at true results in making proper cable recommendations.

It is sometimes economical to extend old plants at the 2400-volt level but new plants should be based on the 4160- or 13,800-volt level. Based on the installed cost of all components comprising the distribution system, a 4160-volt system is more economical than a 13,800-volt system for mill capacities up to about 10,000 k.v.a. For mills in the range of 10,000 to 20.000 k.v.a. capacity, the two are comparable. However, individual comparisons should be made for such large mills. For mills above 20,000 k.v.a. capacity, a 13,800-volt system is the logical selection. If past experience is any guide to future expansion, it would be well to allow ample electrical growth in selecting the main voltage level and system arrangements.

From this information voltage ratings that need be considered in establishing standard cable for use in the pulp and paper industry can now be determined. They are as follows:

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Voltage rating of cable	System voltages
600	230, 460, or 575
5,000	4160 or 2400[a]
8,000[b]	6,900
15,000	13,800

[a] One standard 5000-volt cable is recommended for both the 5000- and 2400-volt service since the new plants are using 4160 volt.
[b] This standard will not be discussed in detail since switchgear ratings in this country are 5 to 15 kv. and therefore, the trend is to eliminate this voltage for distribution systems.

MAIN DISTRIBUTION FEEDER ARRANGEMENTS

It is not the purpose of this paper to go into feeder arrangements. Some facts on this subject are briefly summarized since system arrangements tie in so closely with cable requirements.

It is the concensus that for both low-voltage and high-voltage feeders, the radial system is the most economical and often affords sufficient system reliability. However, on low-voltage distribution systems, larger radial feeders are not always entirely satisfactory in the interest of operating convenience, flexibility, maintenance, and service reliability. Operating records show that most power outages occur on the low-voltage circuits not in the high-voltage distribution system. Therefore, the secondary selective arrangement which does not cost much more than a straight radial system and yet provides duplicate power channels and the high degree of service reliability essential to many paper mill processes, is often used.

SPECIAL CONDITIONS

Corrosion and Moisture

Corrosion and moisture present serious problems in the pulp and paper industry. Moisture can be adequately handled so far as protecting cables from it are concerned. But the combination of moisture with the acid fumes usually prevalent in many plants often results in severe corrosive conditions that are difficult to combat. Flamenol and Neoprene covered cables both show excellent life when operated under these conditions.

Because of the economy of metallic-covered cable used without conduit, studies have been underway for some time to determine what types of metallic covering are best for these conditions. The perfect answer has not yet been found but it is hoped that the completion of these tests will give the solution to this problem. In the meantime, it has been found that galvanized steel coated with black glytal paint and then sprayed with acid-resisting paint gives very satisfactory service.

As was previously pointed out, loads to be handled in this industry are unusually heavy. This means that in selecting economical long-life cables, particular attention must be given to operating the cables at the proper temperatures, that the question of acceptable voltage drops be investigated, and that cables selected have adequate short-circuit capacity.

Heating of Cables

First consider the continuous heating of cables during operation of the plant. Because the amount of current to be handled is high, the most economical safe cables to be used should have high-temperature insulations. Number 1799 varnished cambric, Super-Coronol, Versatol rubber, and similar materials furnished by the various cable manufacturers are the highest temperature insulation of their type obtainable.

Voltage Drop

Whenever proved demands are heavy there is always the question of installing cables which are large enough to keep the voltage drop sufficiently low. By going to higher distribution voltages, voltage drop is appreciably reduced. For example, a typical 1500-foot, 480-volt feeder had a voltage drop of 9% when carrying the rated load. By going to load center distribution with 1400 feet of the feeder operating at 4160 volts and 100 feet operating at 480 volts, the feeder had a voltage drop of only 0.83% voltage. Drop should always be checked but if the high-voltage distribution systems recommended earlier in this paper are used, unless the runs are unusually long, the size of cable adequate to carry the load will be governed by the heating of cable caused by the load carried rather than by the voltage drop.

Short-Circuit Capacity of Cables

Cables like other types of electrical apparatus have very definite short-circuit capacities. Tables I and II give the limits beyond which the insulation will be permanently injured. The first column gives maximum guaranteed copper temperatures which are the basis for normal loading of cables. These limits are based on many years of practical experience and assure the most economical use of cables. An average life of 30 years of useful life can be expected with approximately six failures per 100 miles of cable per year. Bearing in mind that the life of an insulation is cut in half and service failures are doubled with every 5 to 10°C. operating temperature rise, an operator should hesitate to overload his cable except in an emergency. The second column in these tables suggests a maximum emergency rating of cables. The third column should be used to determine the minimum size of conductor that will safely handle the maximum short circuit allowed to feed into the cable by the protective breaker.

Table III is used with Tables I and II to select the

Table I. Varnished Cambric Insulated Cable

Maximum Copper Temperatures (°C.) for Different Conditions of Loading

Voltage rating, kv.	Normal loading	Emergency overloading	Short circuits
	Single-Conductor Cable		
1.0	85	105	150
4.5	85	100	145
7.5	84	94	135
15.0	77	85	120
23.0	70	72	90
	Three-Conductor Shielded Cable		
1.0	85	105	150
4.5	85	100	145
7.5	84	94	135
15.0	77	85	120
23.0	70	72	90
	Three-Conductor Nonshielded Cable		
1.0	85	105	150
4.5	83	98	145
7.5	81	91	135
15.0	70	78	120

Table II

Maximum Copper Temperatures (°C.) for Different Conditions of Loading

Voltage rating, kv.	*Normal loading*	*Emergency overloading*	*Short circuits*
	Code Performance Compound		
0 to 1.0	60	75	140
1.1 to 5.0	60	75	135
5.1 to 8.0	60	73	130
8.1 to 15.0	60	72	125
	Heat-Resisting Compounds		
0 to 1.0	75	86	150
1.1 to 5.0	75	85	145
5.0 to 8.0	75	83	140
	Ozone-Resisting (Oil Base) Compounds		
0 to 1.0	75	83	120
1.1 to 5.0	75	82	115
5.1 to 8.0	75	80	110
8.1 to 15.0	70	75	105

Super-Coronol compound will operate at 80° normal loading and correspondingly higher emergency and short-circuit values.

minimum cable size for a given short-circuit ampere value which must be corrected using the time factors shown. The tables were obtained from data prepared by G. B. Shanklin of General Electric Co.

SELECTION OF CABLES

The following types of cables are, in general, best adapted to the wiring of paper mills.

Generator Leads:

1. Heat-resisting V.C. Flamenol jacket, interlocked armor cables in air.
2. Heat-resisting V.C. lead cables in ducts.
3. Coronol heat-resisting rubber in ducts.

Branch Circuits—0 to 600 volts:

Above 100 amp.:

1. Heat-resisting V.C. Flamenol jacket, interlocked armor cable in air.
2. Heat-resisting V.C. lead cables in ducts for wet location. The same type braided in conduit for dry location.
3. Versatol-Geoprene in ducts or conduit. Flamenol for circuits subject to oil, acids, or alkali.

100 amp. and less:

1. Versatol-Geoprene in conduit or Flamenol for abnormal conditions of oil, acids, or alkalies.

Asbestos, glass, and Silicone insulations are used in hot locations. Their application however, is very limited since their cost is so high that they cannot be justified from an economic standpoint except where no other insulation will withstand the heat.

A brief review of the above cables brings out the following features for each type.

Interlocked armor cable has been available for many years and is fast gaining acceptance with the electrical industry. Among its many advantages are: lower installed cost, savings in space, and reduction in layout time and costs. The installation cost is lower because of savings in material and labor when compared with cable in conduit or insulated bus. A simple guide calls for (a) not using conduit larger than $1^1/_4$ which takes care of circuits up to 100 amp. except for short wall or floor inserts; (b) not using metal-enclosed bus longer than 25 feet except plug-in-bus; and (c) not using building types of wires in sizes No. 1 and larger. The saving in space by using armored cable is often considerable, averaging 50%. This is important in providing additional load to existing building. Reduction in layout time and costs necessary with the conventional conduit systems are often affected and it is possible in most cases to install the job from a single line diagram.

A bulletin GEA-4507 and other technical publications are available giving comparative costs and engineering data on armor cables. A full line of joints and terminal fittings, as well as installation methods, have also been fully developed.

Heat-resisting V.C. leaded cables are used extensively in underground ducts for wet locations. For dry locations in conduit in air, a braided design is most commonly used. Such cables have a comparatively high ampere capacity. The conductor cannot decentralize and the insulation can stand a lot of mechanical abuse.

Versatol-Geoprene and cables of similar construction are fast replacing the conventional types of rubber-braid building wires in industrial plants because they have three outstanding properties: long life, high resistance to moisture, and resistance to heat. They can be buried directly in the ground, installed in conduit or duct, or in the open air for wet or dry locations.

For voltages above 600 volts, cables of similar construction are used except that an ozone-resisting insulation is substituted for the Versatol. Shielding is recommended for many high-voltage applications.

Table III. Insulated Power Cable, Mean Effective 60-Cycle Short-Circuit Current

Duration, 1.0 Sec.

Conductor, size AWG or MCM, No.	*Short-circuit current, amp. Temperature rise above operating temperature, °C. 40*	*50*	*60*	*70*	*80*
14	171	190	202	222	236
12	272	302	321	352	374
10	432	481	511	561	595
8	685	764	810	890	945
6	1,092	1,218	1,291	1,420	1,508
4	1,735	1,930	2,050	2,250	2,390
2	2,760	3,075	3,260	3,580	3,800
1	3,480	3,875	4,110	4,510	4,800
0	4,400	4,910	5,200	5,710	6,060
00	5,530	6,160	6,540	7,180	7,610
000	7,000	7,770	8,250	9,060	9,620
0000	8,800	9,800	10,400	11,430	12,130
250	10,400	11,580	12,300	13,500	14,320
300	13,480	13,900	14,750	16,200	17,200
350	14,500	16,200	17,200	18,900	20,050
400	16,620	18,500	19,650	21,600	22,900
500	20,800	23,150	24,550	27,000	28,650
600	24,900	27,800	29,500	32,400	34,400
700	29,100	32,400	34,400	37,800	40,100
750	31,200	34,700	36,800	40,500	43,000
800	33,300	37,000	39,300	43,100	45,800
1000	41,600	46,300	49,100	53,900	57,200
1250	52,000	57,900	61,400	67,500	71,600
1500	62,400	69,400	73,600	81,000	85,900
1750	72,800	81,000	86,000	94,500	100,100
2000	83,100	92,500	98,200	108,000	114,500

Correction Factors for Other Values of Duration of Short Circuit (Sec.)

Duration, sec.	*Correction factor*	*Duration, sec.*	*Correction factor*
0.1	3.16	2.0	0.707
0.25	2.00	3.0	0.576
0.5	1.4	4.0	0.500
1.0	1.00	5.0	0.447

Flamenol with either a standard wall or a heavy wall is recommended where severe operating conditions such as oil, acids, and alkalies are encountered.

In conclusion, it is believed that by following the four major steps just discussed, a paper mill engineer will be able to provide his mill with the most reliable system and one which will achieve maximum over-all economy.

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DISCUSSION

E. E. McIlveen: (Research Engineer, The Okonite Co., Passaic, N. J.): Mr. Calvert has made a comprehensive analysis of the electrical cable problems which designing and operating engineers are likely to encounter. It is of special interest to note that Mr. Calvert finds neoprene-covered cables show excellent life when operated in the presence of acid fumes and moisture. This has also been our experience with cables used by the paper industry in aerial, riser, and underground installations. It is not surprising for properly compounded neoprene stocks have a reputation of being inherently resistant to acids such as sulphuric and sulphurous, and to alkalies such as caustic soda.

In addition to being very stable in the presence of moisture and the acids and alkalies normally encountered in industry, a good neoprene sheath compound has oil, heat, flame, ozone, and sun-checking resistance. A long-time natural weather aging test conducted in industrial atmosphere at Passaic, N. J., has vividly illustrated this latter characteristic. Two cables, one with a neoprene sheath and the other with a 60% type rubber sheath, were bent in a U shape and exposed to the weather and direct sunlight in January, 1935. Today, after nearly 14 years the Okoprene is physically as good as new—not even a sign of crazing, whereas the rubber sheath exhibits severe cracking. You have undoubtedly noticed this phenomenon in tires, garden hoses, and some rubber-covered portable cords.

Neoprene sheaths are a "natural" on aerial cables, the self-supporting type being widely used around industrial plants. In this construction the required number of single-conductor insulated and neoprene sheathed cables are assembled, either unilay or dualay, and bound to an appropriate messenger by an open helical wrap of a metal tape. Among the advantages are: (1) a self-supporting system is more economical than an underground system, (2) it is easier to add branch feeders to new load centers than if underground, (3) it requires far less space than open wire lines and eliminates cross-arms, (4) has better continuity of service than open wire lines, (5) it has better voltage regulation than on open wire lines, and (6) it permits long spans or awkward installations to be easily made. Some pulp and paper mills are using this type as express feeders, others in distribution circuits between the various buildings. At Canton, N. C., there is a 4160-volt installation which is giving excellent service. Inspection by one of our engineers revealed that although the neoprene sheath and messenger are covered with a sticky viscous condensate which holds fiber particles on the surfaces, there has been no adverse effect upon the cable.

Copperweld messengers and copper binders are widely used in other industries. Some paper mills have found that 18–8 stainless steel behaves well and we have, therefore, furnished cables with stainless steel messengers for locations where concern has been felt over either galvanized steel or copperweld. In these cases there was no need to have high conductivity. Monel metal would also be a good material, but it has not been found to be readily available in messenger form.

There is no need to shield these rubber-insulated neoprene sheathed cables for operation up to 5000 volts, nor is it necessary to strip back the neoprene at splices or terminations. This is a distinct advantage.

For the 15,000-volt rating, a single-conductor insulated-shielded-neoprene jacketed cable is recommended, especially for the self-supporting type. This can also be easily terminated or spliced. Indoor connections, whether to generators, motors, or transformers or in any runs between disconnect switches, current transformers, reactors, and buses, may all be made in a relatively small space using only simple stress-relief build-ups at the ends of the shielding tape. This is of importance where clearances in cubicals is limited. Such a cable also lends itself very well to aerial splicing, and the elimination of aerial work with hot lead is an appealing feature. Incidentally the lighter weight of these nonleaded aerial cables facilitates construction.

Regarding the 15,000-volt underground service mentioned by Mr. Calvert, another solution is available for those locations where corrosion would ruin lead sheaths, namely paper insulated–lead sheathed cable with a neoprene protective covering. This construction has an enviable background and has been so successful that today it is supplied with a reduced lead wall under the protective covering at about the same cost as a regular wall lead sheathed cable. It might be added that we differ from Mr. Calvert in that we feel either rubber or paper insultion is preferable to varnished cambric for 15.000-volt service around industrial power plants. The varnished cambric can be obtained with a neoprene protected lead sheath if desired. Lead sheathed cables require potheads, of course, which makes their use in limited space troublesome.

There is one more important use for neoprene in paper and pulp mills, namely, as a corrosion protective covering over interlocked or flat metal tapes. For example, where three-conductor varnished cambric interlocked galvanized steel or bronze tape cable could be installed within a building but would be subjected to sulphite fumes, a neoprene protective covering could be applied over the metallic tapes. Although adding slightly to the first cost, it would eliminate expensive maintenance and early replacement.

E. W. Davis (Simplex Wire & Cable Co., Cambridge, Mass.): The subject of this paper is a very interesting one and one in which there is a considerable lack of knowledge as to the proper types of electric cables for such important industry. The paper, therefore, is timely and should contribute considerably to the general knowledge of the subject.

We believe that the procedure recommended of 5000-volt cable for use on both 5000- and 2400-volt service is a good one. It provides an extra factor of safety for 2400 volts which is usually an undergrounded system, as well as a chance to shift the system voltage from 2400 to 4160 if it is desired to do so later. The 6900-volt systems are rather infrequent and, as indicated, are becoming less frequent in this industry. We believe that the recommendation here of 8000-volt rated cable is also to be recommended. It is more or less common practice in the industry to use 15,000-volt rated cable for 13,800-volt systems and similar ones. We believe that this offers additional factor of safety and is commendable.

With reference to the types of distribution arrangements, we feel that radial feeders are satisfactory for the high voltage or primary distribution. The secondary selective system is, for the low voltage, almost a necessity. In paper mills, power must be maintained and it is only by such a selective system that it can be under all conditions. Such a selective system is also to be preferred for the high-voltage supply but adds somewhat to the cost of the system, nevertheless, if continuity of operation and utmost reliability are desired, this should be considered.

Corrosion problems in pulp and paper mills are indeed severe, so much so that the trend is definitely away from all metallic outer covering. The insulations for this service must be made to withstand moisture, acids, and alkalies and it is to be presumed that the recommendations made are based upon proper choice of moisture-resistant insulation whatever type is used. We have had a great deal of experience with cables without conduit. The results have been very excellent, however, we have found that for safety reasons some type of shielding must be provided. One of the best ways seems to be to provide a metal shielding tape which is protected by a jacket over all for protection from corrosion. We have found that bronze is good for this service but that galvanized steel, even especially protected, has not been too successful. If metallic shields are provided for safety they should be, as stated above, protected by special corrosion-resistant jackets but it should be fairly easy to ground them frequently since this is necessary. Protection of a material like steel or galvanized steel is only as good as the perfection of the covering used. It, therefore, has been considered good practice to go to materials like bronze which do not rely as heavily on a protective coating.

Under Heating of Cables there is mention of the use of varnished cambric. There seems to be a trend away from this type of insulation to moisture-resistant, high-temperature compounds. This is particularly true of the high voltage where the special moisture-resistant and/or corona-resistant rubber compounds are giving excellent service. These same compounds can be used for the control cables. Thermoplastic materials, such as polyvinyl chloride, are quite suitable.

The method of distribution so as to reduce voltage drop is commendable. With some installations with which we are familiar this system has been worked out with much greater control of load voltages. This means that the load centers must be put very close to the actual work which they must feed. This is also economical since it produces the amount of large size copper needed as pointed out.

The failure rate seems to be slightly higher than the average which we have obtained. We would also like to point out that it is important not to overload continuously and that in some locations it is good practice to watch the ambient temperatures particularly in the Summertime.

If varnished cambric generator leads are used care must be taken that proper end seals and terminations be provided. There have been experiences in this field with varnished cambric cables by breathing bringing moisture into the insulation from the ends and causing trouble. It is, therefore, well to consider the rubber as a better solution and it should be the preferred one for this particular phase of distribution. Here again the rubber compound must be of the moisture-resistant type.

Concerning branch circuits, low voltage, recommendation 1 has the disadvantages mentioned above, but recommendation 2 is not to be preferred since it provides for a metallic outer covering which is not desirable in this type of service. Recommendation 3 could be extended a little better in that neoprene jackets are satisfactory for acids and alkalies if properly compounded. Once again it is well to point out that varnished cambric cables are subject to breathing and that the ends must be carefully sealed to prevent entrance of water or water vapor.

Various insulations are possible at hot locations. We would suggest that Silicone be carefully considered if moisture is present. The space saving is of interest in the use of cables without conduit and is a reality. Also such a type of distribution provides for definitely more flexibility in arrangements of circuits.

We cannot agree that varnished cambric leaded cables are too extensively used for underground ducts for wet locations in this type of service. There is a growing interest in rubber nonleaded types of constructions. Furthermore we doubt very much if any paper and pulp mill should be considered to have any dry places.

Recommendations have been made in this paper for the use of thermoplastic P.V.C. type of insulation. It is our practice to do this on small sizes. However, we feel that large size conductors require rubber or similar thermosetting insulation.

The emergency overloads indicated in the two tables look to be satisfactory. However, it is important that any overloads must specifically state the time for which they can be used. This is most important.

We cannot agree with the third part of Table II in which the ozone resisting compounds are given slightly lower emergency overload ratings and short-circuit current ratings. This may be true of a particular type of compound but is not universally true. The minimum effective short-circuit currents are satisfactory and are presumably based on not figuring any heat storage because of the short times involved.

We believe that the author is to be congratulated on presenting a very clear and concise statement of an important phase of the cable industry.

Determination of Total and Active Alkali in Sulphate Black Liquors

B. L. BROWNING

A comparison of active alkali and total alkali content of sulphate black liquors was made using several methods including TAPPI Standard T 625 m, a modification of this standard involving the addition of formalin, and the procedure developed by Torrey and Nelson.

THE USUAL methods of determining total alkali are based upon conductometric titration with standard acid, or upon ashing a portion of the liquor and titrating the alkalinity in the ash to the methyl orange end point (TAPPI Standard T 625 m). Sodium sulphate and sodium chloride are not included in either method. An alternative procedure is based on the determination of total sodium in the ash, which properly includes sodium sulphate and improperly includes sodium chloride as so-called "recoverable alkali."

Active alkali is usually considered as consisting of sodium hydroxide and sodium sulphide (TAPPI Standard O 400 p). For analysis according to TAPPI Standard T 625 m, the liquor is treated with barium chloride, and the supernatant liquor is titrated to a pH of 8.3 at which point all the hydroxide and half the sulphide have been titrated. The total sulphide sulphur is determined by evolution, and half the value found is added to the potentiometric titration to give active alkali (all calculated as sodium oxide).

It has been pointed out by Moltzau (*1*), in discussing the analysis of white and green liquors, that sodium sulphide in the presence of formaldehyde is completely, rather than half, neutralized at a pH of 8.3. Therefore, it should be possible to determine active alkali (hydroxide plus sulphide) in black liquor by a single potentiometric titration of the barium chloride-treated liquor to a pH of 8.3.

A comparison of active alkali content was made by the formaldehyde modification and the TAPPI Standard on a number of black liquors. At the same time, the total alkali content, as determined conductometrically, was compared with that obtained by the method of Torrey and Nelson (*2*), in which the total alkali of soda liquors was determined by potentiometric titration to a pH of 2.4.

The seven black liquor samples tested represented commercial liquors from two mills and a laboratory cook. These, together with the several wood species, probably represent black liquors of widely variant compositions within the commercial range.

The results of the analyses are given in Table I. The analyses were carried out by D. R. Moltzau and P. S. Baker. The formaldehyde modification differs from TAPPI Standard T 625 m (active alkali) only in that 5 ml. of 40% formalin are added to the solution just before the titration is started. The acid equivalent of the added formaldehyde is determined by separate titration of another 5-ml. portion to pH 8.3 with standard alkali, and this correction is added to the titration of the liquor.

The active alkali, as determined by the formaldehyde modification, was lower in each case than that determined by TAPPI Standard T 625 m, the average difference being 2.5%. It is believed that the formaldehyde modification yields the more nearly correct value, as there is some evidence that, during potentiometric titration to a pH of 8.3 in the absence of formaldehyde, more than half the sulphide is titrated because of some formaldehyde already present in the liquor or of some substance which behaves similarly during the titration. This effect does not appear to be caused by sugars, because the addition of 10- and 15-gram portions of glucose did not appreciably alter the titration curves.

Table I. Composition of Black Liquors by Different Methods of Analysis

Sample	*Liquor*	*Active alkali (Na_2O), g./l. (1)*	*Active alkali (Na_2O), g./l. (2)*	*Na_2S by evolution (Na_2O), g./l. (1)*	*Na_2S by double titration (Na_2O), g./l. (3)*	*Total alkali (Na_2O), g./l. (Conductometric) (1)*	*Total alkali (Na_2O), g./l. (Titration to pH 2.4) (4)*	*pH at which methods (1) and (4) give same total alkali*
1	Weak	2.7	2.6	1.7	1.5	11.5	13.5	3.0
2	Strong	9.3	9.0	6.9	6.4	36.0	41.7	3.1
3	Pine	11.3	10.9	9.3	8.5	45.1	53.2	3.2
4	Hemlock	10.2	10.1	7.0	6.7	38.6	47.1	3.3
5	Balsam	15.2	15.1	5.8	5.5	47.8	55.4	3.1
6	Strong	10.5	10.0	6.6	5.7	38.2	44.2	3.1
7	Slash pine	14.6	14.5	4.1	3.9	35.5	42.2	3.3

(1) By TAPPI Method T 625 m—Titration of barium chloride-treated liquor to a pH of 8.3; sulphide by evolution; total alkali by conductometric titration.
(2) Titration of barium chloride-treated liquor to a pH of 8.3 in the presence of formaldehyde.
(3) The titration difference with and without formaldehyde, calculated as Na_2O, multiplied by two.
(4) Method of Torrey and Nelson (*2*).

The values for sodium sulphide obtained by doubling the titration difference with and without formaldehyde were always less than the sodium sulphide obtained by the evolution method by an average value of 8%. The percentage difference is greater than in the case of active alkali because sodium hydroxide is not in-

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cluded and because, in multiplying the titration difference by two, the error resulting from the titration of more than half the sulphide (titration to a pH of 8.3 without formaldehyde) is doubled. Nevertheless, titration with and without formaldehyde offers a quick and convenient method for determining sulphide content and, if the observed values are increased by approximately 8%, relatively good agreement with values by the evolution method should be found.

The total alkali in the liquors as determined by conductometric titration was compared to that obtained by the procedure of Torrey and Nelson, in which the liquor is treated with barium chloride and titrated to a pH of 2.4 without removal of the insoluble precipitate.

The titration to a pH of 2.4 gave results for total alkali which averaged 18% higher than those obtained by the conductometric method. However, if the pH values at which Torrey and Nelson's titration method gives the same result as the conductometric method are tabulated, it is found that these lie within the range of a pH of 3.0 to 3.3, with an average slightly below a pH of 3.2. Hence, if this titration is carried out to a pH of 3.2, the values obtained for total alkali will be close to those obtained by the conductometric method.

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Equipment for Feeding Liquid Slime Control Toxicants into Pulp and Paper Systems

CHARLES W. DEAN

As paper mills have become more aware of the losses caused by slime, the use of chemical toxicants to control these losses has become more widespread. However, the need for careful control of the dosages of these toxicants in order to obtain maximum benefit has not been so well recognized. Nevertheless, it has been demonstrated by numerous mills that maintaining the proper concentration of toxicant for the proper length of time is necessary if a sound slime-control program is to be realized. To aid in feeding the desired amount of liquid toxicant into the system, dependable feeding equipment may be installed. Two basic feeding equipment systems are discussed. In the first, a small piston-type positive displacement pump is utilized. To this pump is added a rotameter, either indicating or recording, to give a visual or permanent record of the amount fed. In addition, other equipment such as a cycle controller, proportioning equipment etc. may be added. This system is satisfactory but its initial cost is high. A second system utilizes a gear-type positive displacement pump plus a rotameter. These two units cost approximately $100 and provide a reasonably dependable feeding system when used as recommended. The piping arrangement provides for recirculating a portion of the toxicant between the pump and drum. The desired amount is fed into the system through the rotameter by adjusting the bypass valve. Due to the small flow to the system, it has been found impossible to use a valve in the main line and get constant feeding due to clogging of the valve by foreign material. The bypass arrangement overcomes this difficulty. It is believed the utilization of either of these feeding systems, plus a consistently maintained inventory control will help in attaining economical slime control.

It is becoming increasingly well recognized that the pulp and paper industry suffers large losses because of the presence of slime in the mill systems. More and more mills are intensively studying this problem. Once an exhaustive study has been made of the losses being caused by slime, the mill then can organize a sound slime control program based on desirable engineering changes plus the use of chemical toxicants.

The purpose of this paper is not to discuss the desirability of a slime control program, but to discuss equipment which will aid in feeding the desired amount of liquid toxicant into the system.

A point which may be overlooked by mills using slime control agents is the necessity for providing the proper amount of toxicant over the desired period of time each day. It is just as important to maintain the proper concentration of toxicant to get satisfactory results as it is to maintain the correct concentration of any of the many chemicals used in paper making. However, in the case of the toxicant it is somewhat more difficult than with most other chemicals. This is because of two things. First, the toxicants are used at quite low concentrations which increases the difficulty of determining them quickly and reliably by present known methods of analysis. Secondly, the results obtained from adding too much or even too little toxicant to the system are not immediately apparent. Thus, the two usual methods of direct or indirect analysis used in control work for making proper additions cannot be employed at present.

The need for adding the correct amount of toxicant at the desired rate cannot be over-emphasized. If more than the desired amount of toxicant is added to the system, everything moves along satisfactorily until someone analyzes the cost of the program. Then something usually happens quite promptly. On the other hand, if too little toxicant is added on a particular day or shift, trouble may not be apparent for several days. It is then too late to determine what actually occurred unless a dependable toxicant control technique has been installed.

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In general, the best results per dollar of expenditure for any toxicant have been obtained when the toxicant is added over a 2 to 3-hour period each shift or a 2 to 3-hour period once each 24 hours. The amount added should be based on the production for the entire 8 or 24 hours, but added over the shorter period to provide higher toxicant concentrations. To insure obtaining this desired concentration, a dependable feeding system is very helpful. Different systems have been devised with varying results. Some have used orifices and a variable head of liquid to obtain the desired average flow over the feeding period. Others have added the refinement of a constant-head tank principle. Recently, more dependable results are being obtained from two other systems which utilize a chemical feed pump as the primary item of equipment.

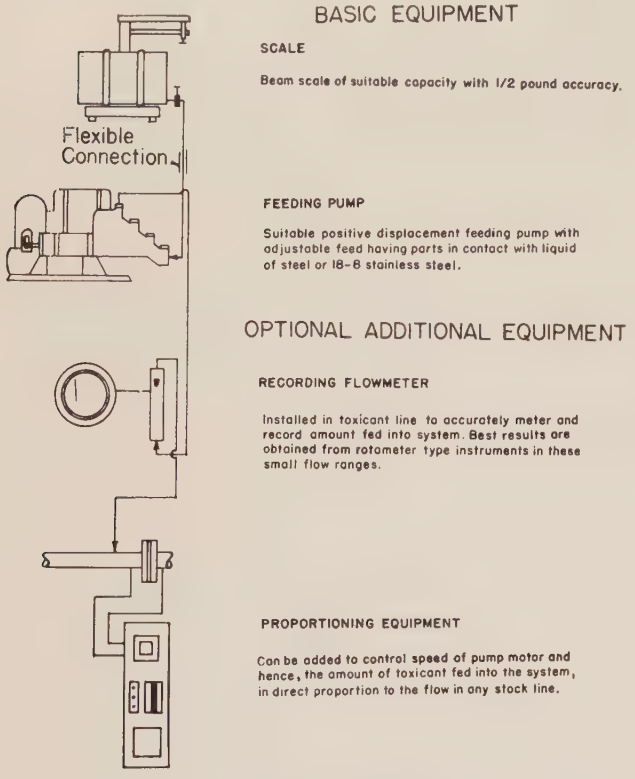
BASIC EQUIPMENT
SCALE
Beam scale of suitable capacity with 1/2 pound accuracy.
Flexible Connection
FEEDING PUMP
Suitable positive displacement feeding pump with adjustable feed having parts in contact with liquid of steel or 18-8 stainless steel.
OPTIONAL ADDITIONAL EQUIPMENT
RECORDING FLOWMETER
Installed in toxicant line to accurately meter and record amount fed into system. Best results are obtained from rotameter type instruments in these small flow ranges.
PROPORTIONING EQUIPMENT
Can be added to control speed of pump motor and hence, the amount of toxicant fed into the system, in direct proportion to the flow in any stock line.

Fig. 1. Equipment for controlled feeding of liquid toxicant directly from drum into mill systems

The first of these systems is illustrated in Fig. 1. Here the pump is a piston-type positive displacement unit. The amount of toxicant fed into the system is varied by adjusting the length of the stroke of the piston. On the model indicated, this adjustment is simply and easily made while the pump is operating.

For a large number of applications this pump would be all that is required. However, if the drum is emptied or the suction line to the pump becomes clogged, the resulting stoppage of flow may not be discovered for some time when only a feeding pump is used. Therefore, the inclusion of a flowmeter is desirable. For the small flows involved in feeding a concentrated toxicant, the only type of flowmeter which has been found accurate enough is the rotameter. By passing the flow through this meter a visual indication of the flow is obtained. If desired, a recording device can be included to provide a permanent record of the amount fed. Other additions can be made to this system to accomplish almost anything which may be required. Cycle controllers, proportioning equipment, can be added to satisfy various sets of conditions.

While the foregoing fulfills the requirements of a satisfactory feeding system, the cost of the system may seem high to some mills. The basic feeding pump costs about $500 with additional equipment about in proportion. An alternate system, which is considerably less expensive, is shown in Fig. 2. Here, a familiar gear-type positive displacement pump plus a rotameter are the two basic pieces of equipment. The combined cost of these two pieces is approximately $100. The installation is as simple as is indicated here. The toxicant delivered by the pump is divided into two streams by the piping arrangement shown. One stream passes through the control valve and back into the original drum. The second stream passes through the rotameter and into the mill system. By adjusting the control valve, any proportion of the total amount being pumped can be diverted through the rotameter up to its capacity. The control valve is located in the bypass line for a definite reason. In many mills the flow rate of toxicant to the system is quite small. This rate may range from a low of 0.1 gallon per hour in some mills to 3 or 4 gallons per hour in others. At these flow rates, it has been found impossible to maintain a constant rate by throttling with a valve in the

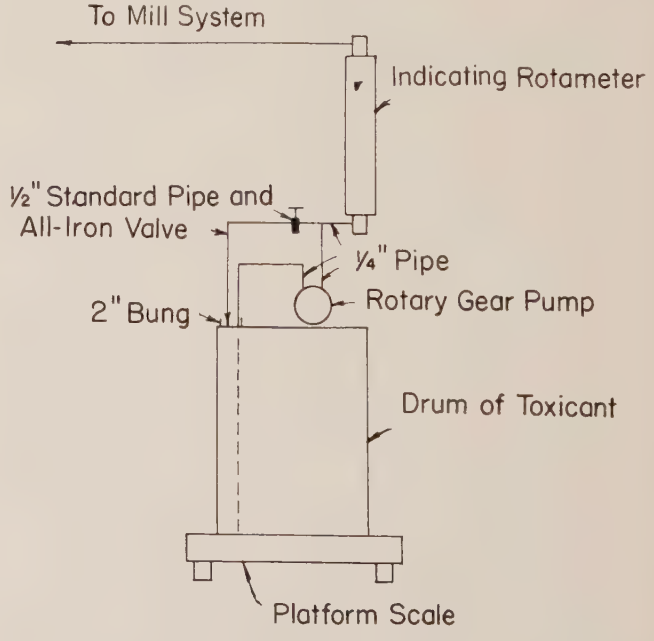

Fig. 2. Simplified equipment for feeding liquid toxicant directly from drum into mill systems

main line. The small opening of the valve which is necessary results in minor amounts of solid foreign material, such as rust etc. plugging the valve and thus causing a reduction in the flow. Therefore, the valve was put in the bypass line where the flow is substantially greater. With this arrangement it has been found that once a predetermined rate was carefully set the rate remained essentially constant. Obviously, the

ratio of the flow back to the drum to the flow into the mill system is inversely proportional to the ratio of the pressures on the two lines. It consequently follows that whenever the back pressure on either of the two lines changes, the flow ratio will change. For the most dependable feeding, therefore, it is preferable for the mill feed line to discharge to the atmosphere. If this is not possible, then any point of constant back pressure may be used.

As in most cases, some dependability and accuracy have been sacrificed here in order to provide a simple and low-cost feeding unit. There are perhaps two major questions to be asked about the system shown in Fig. 2. The first is: When once set for a given flow, how constant will the flow remain? To answer this question, the system was assembled as shown and the meter calibrated. After this, various rates were set on the meter and the system left undisturbed over a 2-hour period. The total amount fed through the meter during the period was then weighed and the amount compared to the theoretical amount as determined from the calibration curve. The results obtained are shown in Table I. These data are shown graphically in Fig. 3.

The second question to be asked is: What is the effect of temperature on the calibration curve? This, of course, varies with the solution being pumped and its temperature-viscosity coefficient. One set of curves were determined in the laboratory using toxicant which has a viscosity of about 30 centipoises at 20°C. Figure 4 shows the results obtained in these runs. These data were obtained by running the same material through the system at the several different temperatures. To minimize temperature variations, each rate was run for only 15 minutes, giving 1 hour's run at each temperature, with a maximum temperature drop of 2°F. during the run at 118°F.

From the above data, it may be said that the gear pump-rotameter system will provide an inexpensive way to feed liquid toxicant into a paper mill system.

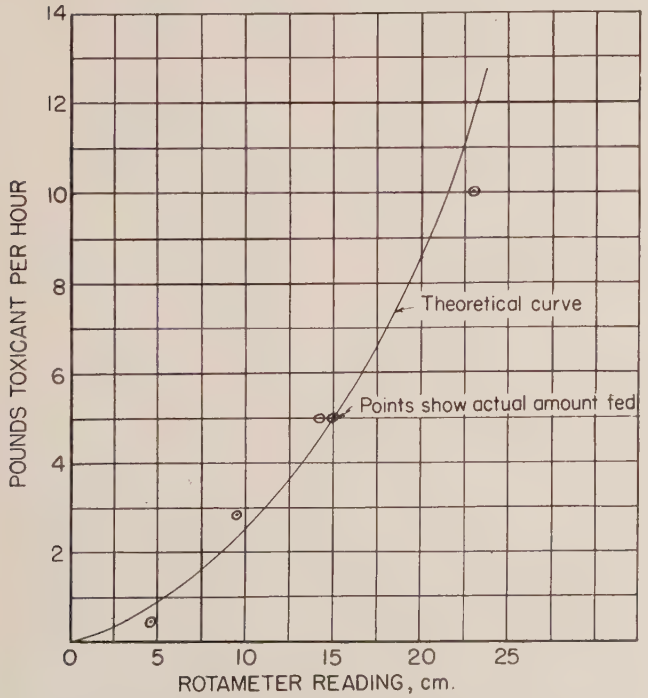

Fig. 3. A comparison of the actual pounds of toxicant delivered per hour to theoretical

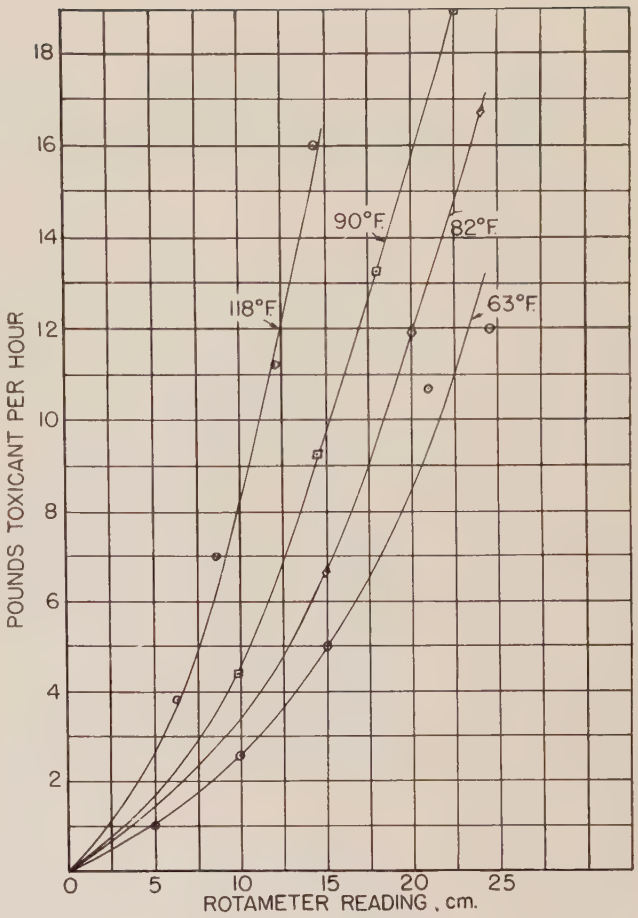

Fig. 4. Effect of temperature on rotameter calibration

Table I. A Comparison of the Actual Pounds of Toxicant Delivered per Hour to Theoretical

Rotameter setting, cm.	*Pounds of toxicant fed per hour*		
	Actual	*Theoretical*	*Difference*
23.0	10.0	11.7	−1.7
14.6	5.0	4.6	+0.4
15.2	5.0	5.0	0.0
9.5	2.8	2.4	+0.4
4.7	0.5	0.7	−0.2

It is not foolproof, however, and good supervision is required to insure that the proper amount of toxicant has been added each period. First, it is obviously necessary from Fig. 3, that the meter should be calibrated at the temperature, or different temperatures, at which feeding is to be done. Secondly, it is recommended that the flow rate be checked by an operator at least every 30 minutes during the addition of the toxicant. As a further check, an accurate weight record, obtained by setting the drum on a simple beam scale and recording the pounds fed each feeding period, is desirable. This weight record is also recommended for use in the piston pump system shown in Fig. 1. The periodic weight tabulation provides a positive check on day-to-day operations and has a pronounced effect on the operators themselves. If such records are consistently maintained in conjunction with suitable feeding equipment, the combined result will be one of material aid in the control of slime.

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Field Use of Sulphite Waste Liquor in Irrigation Water

R. E. STEPHENSON and W. B. BOLLEN

Field experiments over a period of five years were conducted to determine the feasibility of using diluted sulphite waste liquor in irrigation waters. Rates of 10, 20, 40, 80, and 120 tons an acre were applied annually to plots on which potatoes, corn, beans, and cabbage were grown. The various crops were rotated. The results showed that none of the liquor applications had much effect upon the soil after five years of treatment. No consistant effect on the growth of crops was noted. The heaviest rate, 120 tons or about an acre inch was somewhat depressing on the growth of some crops. As a general conclusion, based on field and greenhouse studies, 60 tons or about a half an acre inch can be used annually in dilution with irrigation water without harmful effects.

LARGE AMOUNTS of sulphite waste liquor and wash water must be disposed of daily by the pulp and paper plant of the Crown Willamette Division of the Crown Zellerbach Corporation at Lebanon, Oregon. Preliminary greenhouse studies on the alleviation of the problem by the Oregon Agricultural Experiment Station indicated that a considerable amount of the sulphite waste liquor (S.W.L.) could be applied to growing plants without injury, and perhaps with some benefit (*4*).

The S.W.L., which was obtained from the blow pit, contains sulphur, calcium, magnesium, and a little potassium (*1*), all of which are essential elements for plant nutrition. Since western Oregon soils are frequently deficient in sulphur, especially for those crops having a high sulphur requirement, this element supplied by the S.W.L. seemed most likely to contribute toward increased growth of crops.

Accordingly the Crown Willamette Division of the Crown Zellerbach Corporation provided a tract of land near their Lebanon plant for carrying on experimental work to determine the feasibility of using the diluted S.W.L. for irrigation purposes. This is a report of work started in 1941 and carried on for a period of five years.

PLAN OF STUDY

A series of 36 1/100-acre plots in each of four blocks A, B, C, D were laid out. Treatments are shown for block A in the plan of Chart I, for an irrigation trial in which S.W.L. was mixed with the irrigation water. The rates of use of the S.W.L. were 10, 20, 40, 80, and 120 tons an acre annually. The solids content of the liquor varied from about 7.6 to 8.92%. Each block A, B, C, D had similar treatments, but grew different crops. The soil was Chehalis silt loam, in a good state of fertility.

Chart of Plots

Plan of Project—Use of Waste Sulfite Liquor in Irrigation Water. Plots 1/100 Acre

Plot No.	*Plot series* Block A			
1	No liquor treatment Water only	125 lb. calcium nitrate per acre	125 lb. calcium nitrate and 1000 lb. lime per acre	1000 lb. lime per acre
2	10 tons liquor	10 tons liquor and 125 lb. calcium nitrate an acre	10 tons liquor, 125 lb. calcium nitrate, and 1000 lb. lime an acre	10 tons liquor and 1000 lb. lime an acre
3	20 tons liquor	20 tons liquor and 250 lb. calcium nitrate an acre	20 tons liquor, 250 lb. calcium nitrate, and 1000 lb. lime an acre	20 tons liquor and 1000 lb. lime an acre
4	No treatment Water only	250 lb. calcium nitrate per acre	250 lb. calcium nitrate and 1000 lb. lime an acre	1000 lb. lime an acre
5	40 tons liquor	40 tons liquor and 500 lb. calcium nitrate per acre	40 tons liquor, 500 lb. calcium nitrate, and 1000 lb. lime per acre	40 tons liquor and 1000 lb. lime per acre
6	80 tons liquor	80 tons liquor and 1000 lb. calcium nitrate per acre	80 tons liquor, 1000 lb. calcium nitrate, and 1000 lb. lime per acre	80 tons liquor and 1000 lb. lime per acre
7	No treatment Water only	1000 lb. calcium nitrate per acre	1000 lb. calcium nitrate and 1000 lb. lime per acre	1000 lb. lime per acre
8	120 tons liquor	120 tons liquor and 1000 lb. calcium nitrate per acre	120 tons liquor, 1000 lb. calcium nitrate, and 1000 lb. lime per acre	120 tons liquor and 1000 lb. lime per acre
9	No treatment	500 lb. calcium nitrate per acre	500 lb. calcium nitrate and 1000 lb. lime per acre	1000 lb. lime per acre
	Dry series	Dry	Dry	Dry

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Previously, in greenhouse studies using sunflower as the indicator plant, it was found that a maximum of 80 tons of liquor per acre of 2,000,000 pounds of soil could safely be used (*4*).

Table I. Yields of Irrigated Beans With and Without Sulphite Liquor and Other Treatments

Treatments and rates of treatments per acre		Yields of beans per acre with different treatments								
Sulfite liquor, tons	Calcium nitrate, lb.	Liquor only, lb.	Nitrate only lb.	Liquor and nitrate, lb.	Liquor and lime, lb.	Liquor, nitrate, and lime, lb.	Nitrate and lime, lb.	Lime only, lb.	No treatment, lb.	Average for liquor treatments, lb.
10	125	4080	3240	6240	7200	6816	3720	4925	2640	6084
20	250	8160	6840	6720	6000	8280	8040	6360	5640	7290
40	500	6720	..	5760	6840	7800	..	..	..	6780
80	1000	6240	4320	6000	6720	7440	4800	6240	5760	6600
120	1000	4560	..	4320	5520	5850	..	..	..	5062
	Average	5952	4800	5808	6456	7237	5520	5842	4680	6363

Each treated plot is beside a check plot for comparison.
On all limed plots, ground lime rock was used at the rate of 1000 pounds an acre.
The yield of beans on the dry plots was as follows:
Without treatment: 4440 pounds an acre.
With 500 pounds calcium nitrate and 1000 pounds lime: 4680 pounds an acre.
With 1000 pounds lime: 4440 pounds an acre.
With 500 pounds calcium nitrate: 4200 pounds an acre.

The first year of the study the soil was leveled, although not much top soil had to be moved in the process. Some nitrogen fertilizer and 1000 pounds an acre of lime treatment were made the first season but none after that. The first year potatoes, corn, beans, and cabbage were grown on the blocks A, B, C, D, respectively. No crop ever followed itself on the same plot in successive years, but was switched to a different plot each year.

The 80-ton rate of use was divided into two and the 120-ton rate into three irrigations. The second and third irrigations were July 21 and July 28. These three irrigations completed application of S.W.L. The next two irrigations were with water alone, August 11 and August 20. A total of approximately 15 inches of water or water and S.W.L. was applied for the season. The 120-ton rate of use of S.W.L. is approximately an acre inch. Since it was not known what was a safe

Table II. Yields of Irrigated Corn (Ears) With and Without Sulphite Liquor and Other Treatments

Treatments and rates of treatments per acre		Yields of green ears per acre with different treatments								
Sulfite liquor, tons	Calcium nitrate, lb.	Liquor only, lb.	Nitrate only, lb.	Liquor and nitrate, lb.	Liquor and lime, lb.	Liquor, nitrate, and lime, lb.	Nitrate and lime, lb.	Lime only, lb.	No treatment, lb.	Average for liquor treatments, lb.
10	125	8150	7680	8150	9120	8150	7200	7680	7440	8392
20	250	7200	8150	7200	8640	7680	7680	8150	7680	7680
40	500	7200	..	8640	8150	7920	..	..	..	7477
80	1000	7680	9120	8150	7920	8640	9120	7680	8150	8097
120	1000	8150	..	7680	9600	9120	..	..	..	8637
	Average	7676	8317	7964	8686	8302	8000	7837	7757	8057

The yield of corn ears on the dry plots was as follows:
Without treatment: 8150 pounds an acre.
With 500 pounds calcium nitrate and 1000 pounds lime: 7200 pounds an acre.
With 1000 pounds lime: 6720 pounds an acre.
With 500 pounds calcium nitrate: 7680 pounds an acre.

The S.W.L. was mixed with fresh water at the paper plant before application was made on the field. The 10, 20, and 40-ton rates of liquor were applied all in the first irrigation July 14. The S.W.L. was added to enough water in each case to make approximately a 3-inch irrigation.

dilution, the treatment was divided among three irrigations. Applying all the liquor in two irrigations instead of three probably would have caused no harm as indicated in later trials. A dry plot for comparison with irrigation was maintained on the east side of the irrigated plots.

Table III. Yields of Irrigated Corn Fodder With and Without Sulphite Liquor and Other Treatments

Treatments and rates of treatments per acre		Yields of green corn fodder per acre with different treatments								
Sulphite liquor, tons	Calcium nitrate, lb.	Liquor only, lb.	Nitrate only, lb.	Liquor and nitrate, lb.	Liquor and lime, lb.	Liquor, nitrate, and lime, lb.	Nitrate and lime, lb.	Lime only, lb.	No treatment, lb.	Average for liquor treatments, lb.
10	125	22,080	23,060	20,640	13,440	15,360	19,690	20,640	21,600	17,880
20	250	15,840	17,280	16,320	15,360	17,760	17,760	16,800	15,360	16,320
40	500	15,360	....	17,280	18,240	17,760	....	....	....	17,160
80	1000	17,280	23,060	17,760	15,360	14,880	26,880	15,360	20,160	16,220
120	1000	17,280	....	14,480	15,360	13,440	....	....	....	15,140
	Average	17,568	21,133	17,296	15,552	15,840	21,443	17,600	19,040	16,544

The yield of corn fodder on the dry plots was as follows:
Without treatment: 14,400 pounds an acre.
With 500 pounds calcium nitrate and 1000 pounds lime: 12,000 pounds an acre.
With 1000 pounds lime: 8,160 pounds an acre.
With 500 pounds calcium nitrate: 13,440 pounds an acre.

The yields, calculated to an acre basis for the different crops, are presented in Tables I to V, respectively. The data indicate that the 120-ton rate of treatment may have been somewhat injurious to the beans, though there is considerable variability in yields with the different treatments, due in part to attacks by the spotted beetle coming from the adjoining alfalfa field. The first check plot next to the alfalfa on the west yielded 2640 pounds or less than half the yield of the other two check plots. An early fall rain partially eliminated the difference between irrigated and dry beans. Most of the S.W.L. treated plots somewhat outyielded the plots receiving no S.W.L.

The quality of the potatoes was poor. They were knobby and hard, due primarily to fall rains which caused a second growth after the potatoes were nearly mature. The potatoes were also affected with wire worms which were present in the soil. Neither of these difficulties had any connection with the use of S.W.L.

Four crops, corn, beans, potatoes, and sugar beets, for seed production were included in the second year's study. The sugar beets failed but not on account of the S.W.L., however. The treatments with nitrate of soda and lime were omitted this year because of increased difficulties of carrying on such detailed studies.

Table IV. Yields of Irrigated Cabbage With and Without Sulphite Liquor and Other Treatments

Treatments and rates of treatments per acre		*Yields of cabbage per acre with different treatments*								
Sulphite liquor, tons	*Calcium nitrate, lb.*	*Liquor only, lb.*	*Nitrate only, lb.*	*Liquor and nitrate, lb.*	*Liquor and lime, lb.*	*Liquor, nitrate, and lime, lb.*	*Nitrate and lime, lb.*	*Lime only, lb.*	*No treatment, lb.*	*Average for liquor treatments, lb.*
10	125	31,680	32,880	33,600	34,320	40,560	33,600	33,120	30,480	35,040
20	250	27,840	32,880	34,080	36,960	39,860	36,240	40,320	24,000	34,685
40	500	35,520	....	40,080	31,680	37,920	....	....	....	36,300
80	1000	31,440	42,000	40,560	36,960	43,670	45,120	29,520	28,080	38,157
120	1000	37,440	....	41,760	26,920	42,480	....	....	....	37,150
	Average	32,784	35,920	38,016	33,368	40,898	38,320	34,320	27,520	36,266

The yield of cabbage on the dry plots was as follows:
Without treatment: 30,480 pounds an acre.
With 500 pounds calcium nitrate and 1000 pounds lime: 45,120 pounds an acre.
With 1000 pounds lime: 29,040 pounds an acre.
With 500 pounds calcium nitrate: 40,080 pounds an acre.

The data of Table II indicate that S.W.L. had little effect on the yield of ear corn, or on the yield of fodder. The dry plots likewise yielded nearly as well as the irrigated.

The use of S.W.L. had some stimulating effect on cabbage. The best yields, however, were from those plots receiving nitrate or nitrate and lime. The dry plots receiving nitrate yielded as well as those receiving irrigation. The cabbage was late and the early fall rains compensated for lack of irrigation. All cabbage plants were watered with a hose at the time of setting to insure a good start in the field.

S.W.L. in the irrigation water had little effect on the potatoes. The use of nitrate produced a slight increase in yield. There is likewise little increase from irrigation over the yield of dry plots. The low yield of the dry check plot is probably more accidental than significant.

The responsibility for carrying out the work of planting and producing the crops was assumed by the Crown Willamette Paper Company under the supervision of the soils department of the Oregon Agricultural Experiment Station.

The same soil site and liquor treatments as were used in 1941, were repeated in 1942. The application of water and liquor was made in the same manner and at similar rates as in the previous year. No dry plots were left for comparison with those receiving irrigation.

The first liquor treatment was on August 7, 1942. At this time all the liquor of the 10-, 20-, and 40-ton treatments was applied. The 80-ton rate was divided into two applications of 40 tons each, and the 120-ton rate, two applications of 60 tons each, applied at different irrigation periods. The second application was made a week after the first. The other plots received

Table V. Yields of Irrigated Potatoes With and Without Sulphite Liquor and Other Treatments

Treatments and rates of treatments per acre		*Yields of potatoes per acre with different treatments*								
Sulphite liquor, tons	*Calcium nitrate, lb.*	*Liquor only, lb.*	*Nitrate only, lb.*	*Liquor and nitrate, lb.*	*Liquor and lime, lb.*	*Liquor, nitrate, and lime, lb.*	*Nitrate and lime, lb.*	*Lime only, lb.*	*No treatment, lb.*	*Average for liquor treatments lb.*
10	125	21,120	24,480	18,240	20,640	19,200	24,000	23,060	21,600	19,800
20	250	21,600	23,060	24,480	28,800	28,800	24,980	24,480	28,320	25,920
40	500	24,000	....	26,400	19,690	26,400	....	....	....	24,122
80	1000	23,520	24,000	24,980	22,080	22,560	26,880	20,640	21,600	23,285
120	1000	23,060	....	21,600	19,200	21,120	....	....	....	21,245
	Average	22,660	23,847	23,140	23,422	23,616	25,287	22,727	23,840	22,874

The yield of potatoes on the dry plots was as follows:
Without treatment: 13,440 pounds an acre.
With 500 pounds calcium nitrate and 1000 pounds lime: 22,560 pounds an acre.
With 1000 pounds lime: 20,640 pounds an acre.
With 500 pounds calcium nitrate: 20,160 pounds an acre.

plain water at the same time that the liquor-treated plots received their treatments. The last irrigation for all the plots, August 25, was water only.

The crop yields were converted to an acre basis and are reported in Table VI.

Table VI. Effect of S.W.L. Applications on Crop Yields

Treatment	Acre yields—1942			
	Beans, lb.	Ear corn, lb.	Fodder, lb.	Potatoes, lb.
Water only	6240	5558	7182	14,667
Liquor 10 tons	7620	5472	4019	16,800
Liquor 20 tons	8160	6883	6840	24,400
Water only	7920	8123	7182	29,466
Liquor 40 tons	8640	11414	10260	28,933
Liquor 80 tons	7320	7567	8550	26,666
Water only	9360	10688	8465	26,400
Liquor 120 tons	8100	8892	9063	24,133
Water only	6540	10217	8550	22,333
Average of water only	7515	8645	7845	23,217
Average of liquor treatments	7968	8046	7746	24,186

A study of the data indicates that the S.W.L. has not depressed the yield of any of the crops or at any of the rates used. Neither did the S.W.L. affect the stand or the quality of produce so far as outward indication could serve as a basis for judgment. The quality of beans was described as good with the pods well filled. The sweet corn produced ears that were well filled and richly flavored. The potatoes were poor quality, uneven in size and knotty. Use of the S.W.L. had no relation to the poor quality of potatoes, however.

Three crops, corn, carrots, and tomatoes were grown the third year. Lima beans grew vines but failed to mature beans, possibly because of seasonal conditions. Sugar beets carried over from the previous year winterkilled to such an extent that they were plowed up. The responsibility of carrying out the work of planting, producing, and handling the crop was assumed by R. D. Waddell of the Crown Willamette Paper Company in cooperation with the Soils Department of the Oregon Agricultural Experiment Station.

Table VII. Effect of S.W.L. Treatments on Crop Yields

Treatment	Acre yields—1943		
	Ear corn, lb.	Carrots, lb.	Tomatoes, lb.
Dry	13,315	34,848	48,150
Water only	11,236	51,110	43,900
Liquor 10 tons	14,503	58,080	59,600
Liquor 20 tons	12,573	46,464	54,150
Water only	15,295	60,403	59,750
Liquor 40 tons	12,969	52,272	51,150
Liquor 80 tons	12,969	52,272	51,150
Water only	14,107	55,176	70,550
Liquor 120 tons	11,929	40,656	49,300
Water only	10,543	46,464	65,500
Average for water only	12,795	53,288	59,925
Average for liquor treated	13,048	49,716	53,720
Dry plot	13,315	34,848	48,150

The soil site and liquor treatments were the same as previously used. The first irrigation started July 28. At this irrigation the 10-, 20-, and 40-ton treatments, with the proper dilutions with water, were applied. Only half the 80 and the 120-rates was applied at the first irrigation. The second irrigation started August 6 completed the application of the 80- and 120-liquor treatments. The other plots which had already received their quota of liquor received only water at this irrigation. No more irrigations were made during the season.

The production converted to the acre basis is given in Table VII.

The data indicate that the 120-ton rate is probably having some injurious effect on carrots and tomatoes. Some tomatoes were killed by the heavy rate, and the growth of carrots, corn, and beans was stunted. Carrots were irregular in shape and size but yielded well.

After three years' production of cultivated crops, it was decided to seed all the plots to forage plants which would require little care.

The experimental area was plowed April 29, the land was prepared and seeded to grass or a legume on May 3, 1944.

The plots and seedings were:

1. Alta fescue.....16 lb./a.
2. Creeping red fescue.....12 lb./a. } Mixed
   White clover..... 3 lb./a. }
3. Red clover..... 6 lb./a. } Mixed
   Perennial ryegrass.....10 lb./a. }
4. Grimm alfalfa.....10 lb./a.

The purpose of seeding to grass, clover, and alfalfa was twofold (1) to test the response of the seedings to the use of the waste liquor in the irrigation water; (2) to continue the plots with the minimum of attention for the duration. Mr. Waddell of the Crown Willamette Paper Company assumed responsibility for the care of the plots.

The stands of grass, clover, and alfalfa were poor and weedy on all plots, and no yields were obtained. The plots, however, received their regular treatment of the S.W.L. in the irrigation water. Samplings of the soils from the various plots were made after five years of treatment, and subjected to chemical analysis to determine the effect of S.W.L. on the composition of the soil.

The effect of S.W.L. on the soil flora has been reported (*1*).

Organic matter was determined by the Walkley-Black method (*7*), total carbon by the dry combustion method, and total nitrogen by the Kjeldahl method. Available phosphorus was determined by the method of Truog (*6*), and soluble calcium was determined by treating the soil with 0.05 *N* hydrochloric acid and leaching by suction until 500 ml. of leachate was obtained from a 10-gram soil sample. The potassium was then determined by the cobaltinitrite procedure (*2*), and calcium in the usual manner as oxalate titrated with standard permanganate solution. Granules larger than 1 ml. were determined by the use of wet sieves (*5*).

The organic matter, carbon, nitrogen, and carbon-nitrogen ratio, as presented in Table VIII, fail to show any material change in the soil as a result of the S.W.L. treatments. The carbon-nitrogen ratio is rather wide for the whole area. The samples taken both to the east and to the west of the regular plots were not much different from the plots. The west samples were farthest away from the paper plant. Sawdust or hog-fuel used by the plant caused cinders to be scattered rather profusely over the whole area,

Table VIII. Organic Matter, Carbon, and Nitrogen in the Soil

Plot	Treatment	Organic matter, %	Carbon, %	Nitrogen, %	C/N ratio
1	Check	5.09	3.55	0.193	18.3
2	10 tons S.W.L.	5.54	3.77	0.200	18.9
3	20 tons S.W.L.	5.47	3.36	0.191	17.6
4	Check	5.40	3.63	0.191	19.0
5	40 tons S.W.L.	5.40	3.74	0.198	19.0
6	80 tons C.W.L.	5.06	3.51	0.185	19.0
7	Check	5.06	3.46	0.186	18.6
8	120 tons S.W.L.	5.19	3.54	0.193	18.3
	West of plots	5.10	3.11	0.201	15.5
	East of plots	5.97	4.11	0.210	19.6

which may possibly account for the wide carbon-nitrogen ratio.

There is likewise little effect from the S.W.L. on soluble nutrients as indicated in the data of Table IX.

Table IX. Soluble Potassium, Calcium, Phosphorus, and the Granulation

Plot	Treatment	Granulation, %	Soluble calcium, p.p.m.	Potassium, p.p.m.	Available phosphorus, p.p.m.
1	Check	2.67	5750	625	145
2	10 tons S.W.L.	3.07	5920	668	151
3	20 tons S.W.L.	3.72	5860	612	145
4	Check	4.50	5780	599	148
5	40 tons S.W.L.	5.22	5960	622	131
6	80 tons S.W.L.	5.18	5920	532	128
7	Check	5.08	5790	544	142
8	120 tons S.W.L.	4.62	5560	525	126
	West of plots	6.22	5870	467	171
	East of plots	4.12	6410	759	171

The data of Table X indicate no consistent change in pH due to the use of S.W.L. on the soil.

Table X. The pH[a] and Total Sulphur of Lebanon S.W.L. Irrigated Plots

Sample No.	S.W.L. used	pH	Total sulphur, p.p.m.	Sample No.	S.W.L used	pH	Talot sulphur, p.p.m.
1A	None	6.0	370	6A	80 tons	6.2	410
B		5.3		B		5.6	
C		5.9		C		5.7	
D		5.1		D		5.8	
2A	10 tons	6.2	480	7A	None	6.2	290
B		6.1		B		6.0	
C		6.2		C		6.0	
D		5.0		D		6.2	
3A	20 tons	6.1	480	8A	120 tons	6.2	300
B		6.2		B		6.1	
C		5.9		C		5.9	
D		6.2		D		6.2	
4A	None	6.3	350	1E	...	6.2	250
B		6.2					
C		6.0		2E	...	6.1	430
D		5.9					
5A	40 tons	6.2	430	1W	...	6.2	290
B		6.3					
C		5.4			...	6.2	530
D		5.4		2W			

[a] By L & N glass electrode, using 1:5 suspension.

Total sulphur was determined on composite samples of each of the plots, A, B, C, D, by the use of magnesium nitrate as the oxidizing agent.

Five grams of water-free soil ground to pass a 40-mesh screen, were treated with 7 ml. of magnesium nitrate (1000 grams $Mg(NO_3)_2$ per liter), dried on a water bath and ignited at 600°C. To the cooled residue was added 10 ml. of water, 10 ml. of HCl, and 5 ml. of HNO_3, the dish covered and digested 2 hours on a water bath. The material was stirred two or three times during digestion.

The sample was diluted to 250 ml. in a beaker with hot water, mixed, filtered with suction, and made up to 500 ml. with water.

An aliquot was treated with an excess of powdered $BaCl_2$ crystals and allowed to stand over night to develop turbidity. The turbidity was then read in a Leitz photoelectric colorimeter using a red filter. The yellow color did not pass the red filter and did not influence the readings.

The results do not indicate a consistent build-up in the sulphur content of the soil. Since the soil was sampled only to the cultivated depth, 8 inches, it is not known whether leaching may have carried the S.W.L. to greater depths in the soil, or whether the good drainage of the soil resulted in complete removal. The E and W samples outside the range of plots on the east and west sides respectively are of unknown treatment.

SUMMARY

None of the liquor applications, 10, 20, 40, 80, and 120 tons per acre annually, had much effect upon the soil as indicated by data obtained from soil samples taken after five years of such treatments.

Likewise there was no consistent effect of any of the treatments upon the growth of crops produced during the period of treatment. The heaviest rate of treatment, 120 tons or about an acre inch, was somewhat depressing to growth of some crops. This is in agreement with results by Sowden and Atkinson (*3*), using a S.W.L. which contained nitrogen. They received a response in crop growth in the greenhouse from the liquor containing nitrogen, but none from liquor which contained no nitrogen.

As a general conclusion, based on field and greenhouse studies, 60 tons or about a half an acre inch of liquor used annually in dilution with irrigation water seems unlikely to harm either the immediate crops receiving treatment or the soil. Where irrigable land and water are available, the S.W.L. could be safely disposed of by turning the liquor into the irrigation system to be used on the land.

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Determination of the Mold Resistance of Paper and Paperboard

JOHN W. APPLING, STANLEY J. BUCKMAN, and CONAN D. CASH

The Bulab method for the determination of the mold resistance of paper and paperboard is described with recommendations as to the suitability of certain specified test organisms.

Increased interest in the use of mold-resistant paper and paperboard for various types of packages has stressed the need for further work on the development of better methods for determining the degree of mold resistance obtained with various toxicants and methods of treatment. Shema (*2*) has described a method for use with paper and paperboard which is similar to the one reported by Thom, Humfeld, and Holman (*4*). The latter method was used quite extensively for early evaluation of the mold resistance of treated cotton textiles. In the Shema adaptation, a 2 by 2 inch square of paper is placed on the surface of a solid culture medium composed of agar and nutrient salts. A spore suspension of the test organism then is used to inoculate the paper surface and the culture incubated for 2 to 3 weeks. The effectiveness of the treatment is determined by visual examination. Shema states that any specimen which supported growth was regarded as unsatisfactory. In making the examination, growth along the cut edges was disregarded.

Cruickshank (*1*) studied the effect of a number of variables involved in the use of a method similar to the one just described. His method differed from the Shema method in the use of Sabouraud dextrose agar and in the method of inoculating the paper specimens. The results showed that varying the paper to agar ratio yielded data varying in interpretation from that of effective mold resistance to that of no apparent protection. The choice of a test organism, the pH of the agar medium, and the length of the period of incubation were reported to have a similar effect upon the interpretation of the test results.

The ideal test method for paper and paperboard would be one which provides an environment comparable to the most severe conditions encountered in the actual use of the products from the standpoint of the growth of mold organisms. Such an ideal is never completely realized and the test method must of necessity incorporate a reasonable factor of safety. However, it seems clear that the inclusion of agar in the test environment does not contribute the type of increase in severity of the test method which might simulate the more severe conditions of exposure in commercial service. Such service may involve the gradual loss of toxicants with higher vapor pressures by volatilization over fairly long periods of time. It also may involve dilution of the toxicant and possibly minor amounts of leaching as the result of the paper or paperboard becoming damp during some unusual exposure. However, it does not involve placing the paper in contact with a high relative weight of a gel, such as agar, which introduces factors of adsorption and inactivation of toxicants by the gel in addition to diluting the toxicant by diffusion through the gel.

With the factors described in the foregoing in mind, work was initiated in our laboratories on the development and evaluation of a test method which would better simulate service conditions without becoming unreasonably complex or unwieldy. The method that was developed is designated as the Bulab Method and is described in the following:

BULAB METHOD

Test Organisms

Four test organisms are recommended from which at least two shall be selected for use in each test. Those recommended are: *Chaetomium globosum, Penicillium sp.* (Isolate 66, Lever Brothers Company), *Aspergillus versicolor,* and *Aspergillus niger.*

The cultures of the organisms used as the source of the inoculum shall be grown on malt agar either in tubes or in flasks. The cultures shall be incubated at 28°C. for 7 days. Sufficient mineral salts medium shall be added to the malt agar culture so that a heavy spore suspension will result. This in turn shall be transferred to an 8-ounce narrow-mouthed Pyrex glass bottle containing sterile glass beads to a depth of 0.5 inch and approximately the volume of sterile mineral salt medium needed as inoculum. The mixture shall be shaken to obtain a uniform spore suspension.

The mineral salt medium shall have the following composition:

Tap water	1000 ml.
NH_4NO_3	3.0 grams
K_2HPO_4	1.0 gram
KCl	0.25 gram
$MgSO_4 \cdot 7H_2O$	0.25 gram

The pH shall be adjusted to 7.0. The bottles containing glass beads and mineral salt medium shall be sterilized at 15 p.s.i. of steam pressure (121°C.) for 20 minutes.

Procedure

One 2- by 2-inch square shall be cut from each specimen in the set of three from each unit for test against each organism. Thus a total of six specimens

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will be required from each unit based on using two test organisms. The number of units sampled will depend upon the number involved in the lot or shipment and will vary from 5 to 20 (*3*).

Any suitable paper or paperboard may be used as the source of control specimens to establish the viability of the inoculum employed in each test. Two control specimens shall be inoculated with each test organism.

Each specimen shall be carefully handled during cutting and subsequent placing in a sterile Petri dish.

Each specimen shall be dampened by the addition of sterile mineral salt solution to one surface of the specimen. The volume added will depend upon the thickness and nature of the paper specimen and may vary from 0.2 to 2.0 ml. After the solution has been absorbed by the specimen, the latter shall be turned over aseptically with sterile forceps.

Since two test organisms will be used, the dishes with specimens shall be separated into two series for convenience during inoculation. One milliliter of the spore suspension from a 7-day old culture of the first test organism shall be added to each of the specimens designated for test against the organism. Immediately following each addition, the suspension shall be spread uniformly over the specimen with the tip of a pipet.

The same procedure shall be used for the specimens to be inoculated with the second test organism.

After the spore suspension has soaked into the specimens, each dish shall be sealed with a wide rubber band. The sealed specimens shall be incubated at 28°C. for 14 days.

At the end of 7 and 14 days each specimen shall be inspected visually for growth of the test organisms. Specimens completely free of growth at the end of 14 days shall be classified as "mold resistant." It is recognized in making the classification that specimens supporting only a small amount of growth under the particularly favorable test conditions may have adequate mold resistance for some use requirements.

DISCUSSION

The selection of the most suitable test organisms is subject to some difference of opinion. Four different test organisms are listed in the method and the authors recommend including at least two organisms in tests to determine the mold resistance of paper and paperboard.

Chaetomium globosum has been used extensively for tests of this general type. It is a particularly stable organism which grows well on untreated paper and paperboard and is not appreciably inhibited by the presence of bacterial growth in the paper. It is not one of the most resistant organisms to toxicants but it has what might be termed an average resistance and is not particularly sensitive to certain types of toxicants.

Penicillium sp. (Isolate 66, Lever Brothers Company) grows well on untreated paper and paperboard under the test conditions employed. It was isolated from molded soap wrap and, in view of the relative importance of mold resistance to the soap industry, this organism should be carefully considered as a test organism.

Aspergillus versicolor is included in the group and

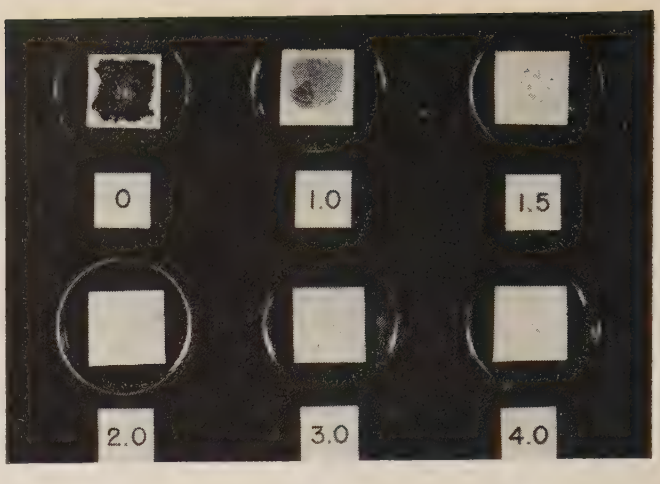

Fig. 1. Untreated and treated paperboard specimens after 21-day test for mold resistance by the Bulab method using* Chaetomium globosum *at 28°C. Numbers refer to pounds of toxicant per side per ton of paperboard. (Test terminated May 5, 1949)

recommended for consideration primarily on the basis of the experience of Cruickshank (*1*) with this organism. In a few tests which the authors made with this species of *Aspergillus* on untreated paperboard, it did not seem to grow as well as *Penicillium sp.* No. 66 and the latter organism, therefore, was selected for use in our work.

Aspergillus niger is a widely distributed mold organism and has been used as one of the test organisms for many types of mold resistance tests of different treated materials, particularly noncellulosic materials. However, it has not grown as well as *Chaetomium globosum* and *Penicillium sp.* No. 66 on untreated paper and paperboard in several tests the authors made with this test organism.

The authors recognize what may seem to be an indefinite description of the amount of mineral salt solution used to dampen paper and paperboard prior to inoculation. However, no evidence has been obtained indicating that the amount of the solution is critical within reasonable limits. The mineral salt solution is added to provide what the authors feel is the minimum contribution which can be made to the welfare of the test organism without creating an environment that departs to an undesirable degree from the more severe conditions of service.

A spore suspension is used to provide uniformity of inoculation of the specimens. Dispersion of the spores in the mineral salt solution also provides for dampening of the opposite side of the test specimen with the salt solution and inoculation in one operation.

During the course of test work on a large number of specimens, observations were made at the end of 7, 14, and 21 days incubation. No cases were noted in which the specimens would have been classified differently based on a 21-day incubation period compared to 14 days. In fact, maximum growth was usually achieved during the 14-day period.

In reporting growth data for the incubated specimens, it is customary to record the growth of the test organism as well as the presence of contaminating organisms. For example, Fig. 1 shows the growth of *Chaetomium globosum* on an untreated specimen of paperboard and no growth of this test organism on

specimens representing five different treatments. However, the specimen from the lowest treatment is supporting the growth of a contaminating mold. Obviously specimens may contain mold spores which are more resistant than those of the test organism and, if so, growth of these will occur. It is questionable whether such specimens shall be considered mold resistant for in a strict sense they are resistant only to the test organisms under the conditions of their use. The authors actually report such cases as showing no growth of test organism, but as showing growth of contaminating molds.

The authors have used the Bulab Method for evaluating the mold resistance of a variety of paper and paperboard samples. The method is simple and involves the use of a minimum amount of equipment. It thus is particularly suited for use in paper mill laboratories in the control of the production of mold-resistant paper and paperboard. It is reported at this time because of the need for such a method with the recognition that continued use may well result in improvements.

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Mechanism of Water Resistance

The Effect of Beating

WILLIAM S. WILSON

In two previous papers it was indicated that the exterior surfaces of pulp fibers were made completely hydrophobic by engine sizing, and three tests for measuring sizing were suggested. These tests seem scientifically more readily justifiable and more informative practically than some of the standard tests now in use. These new tests are the equilibrium water pickup, the wet break test, and the liquid water permeability tests. These three tests were tried on several series of pulps beaten to different degrees of freeness. On water leaf sheets all three tests showed improvement with increased beating. On sized sheets, however, all tests gave higher results, but the order was reversed. That is, the more highly-beaten pulps showed poorer results than the lightly-beaten pulps. These data indicate that lightly beaten or large fibers get a tremendous boost out of sizing procedures that have very little effect on highly-beaten pulp. The author considers this as confirmation of his idea that the relatively large rosin particles do not stick readily to very small fibrils, and that the water found in the equilibrium water pickup test is not necessarily all inside the fibers (as was previously thought), but some of it may be between the tiny unsizable fibrils. Certain interesting relationships between the tests are shown graphically.

In two papers presented at local sections, but not published, three tests for measuring engine sizing were suggested. The basis for recommending the tests was that they were scientifically more easily justified and more informative practically than the tests usually considered as standard.

The work here reported was done to study the effect of beating on these three tests. The appearance of some interesting side lights on the mechanism of engine sizing made it seem worth presenting at this time.

The tests were suggested as a result of work reported earlier by the author (*Tech. Assoc. Papers* 31: 157–161 (1948)) in which it was indicated that the exterior surfaces of fibers are made completely hydrophobic by engine sizing. Any water picked up by the immersed sheet hence must be inside the fibers.

The three suggested tests are as follows: The equilibrium water pickup is the percentage increase in weight on 1 hour's immersion. The water permeability is measured by the drop in a calibrated manometer on a penescope when the recess in the closure ring is filled with powdered sugar. On hard-sized sheets water can get through only as fast as it is removed from the other side. The sugar is used as a capillary active aid to get the reading up to a noticeable figure. The wet break tests are made by attaching weights to the ends of 1.5 cm. strips of paper, immersing the whole assembly, and recording the number of seconds before the strip breaks. By using several weights one may plot curves showing the breaking time for any desired weight.

Four freenesses of a sulphite pulp were made into waterleaf and reasonably hard-sized sheets (2.5% rosin and 3.5% alum). Figure 1 shows the wet break test for the eight types of sheets. The freeness (Canadian Standard) appears as figures on each line. The lines fall into two groups. In the waterleaf group wet strength increases as beating is increased. In the sized group wet strength increases as beating is decreased. Sizing has completely reversed the normal order of wet strength increasing with increased beating.

Another way of describing the same data is to say that sizing has given a big boost to wet strength on lightly beaten pulps and only a relatively small boost on highly-beaten pulps. Considered in this manner, it becomes obvious that luck played some part in getting complete reversal. A small amount of size might not have moved the 593 ml. pulp up even as far as the 111 ml. waterleaf sheet. In other words, each amount of size might cause a different relative movement in the different freenesses and, therefore, a different order for the size curves. The spread between

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the same freenesses on the waterleaf sheets might vary greatly with the kind of pulp. One could at least imagine a case where this spread might be so large that no amount of size could bridge it and the order would remain unchanged. One also might imagine a sheet so open that it had little or no dry strength to preserve by keeping water away from the fiber contacts.

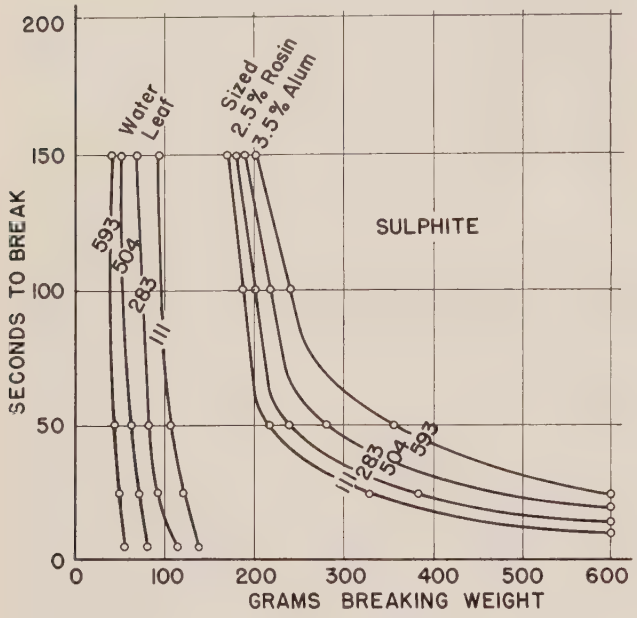

Fig. 1

Notice that the sized curves, if extended, would probably eventually cross the waterleaf curves. More will be said about this later.

Knowing that engine sizing consists of attaching discreet rosin particles to pulp fibers by means of aluminum bonds, a possible explanation for this complete reversal presents itself. It isn't the only explanation possible but it appeals to the author because he had the basic idea several years before he had these data to substantiate it. In other words, the explanation was not conjured up to explain the data but the data clicked with a previously thought up hypothesis.

There is a tremendous amount of turbulence incident to paper making. One lone aluminum bond could scarcely be expected to hold a relatively enormous rosin particle to a pulp fiber in the midst of such turbulence. A spherical rosin particle would not stick to a cylindrical fiber because the one point contact would not permit a sufficient concentration of bonds to hold it there. It would seem that a multiplicity of bonds such as might occur at a nest on the fiber would be necessary to assure adherence. The probability of occurrence of such nests would be highest on large fibers and practically absent on fibrils of say $^1/_{10}$ the diameter of the rosin particle. In other words, as pulp is beaten the amount of unsizable surface may be increased. Furthermore these fine unsizeable fibrils are more tightly squeezed together by surface tension as the sheet is dried. Thus as pulp is beaten, there is a progression from a majority of large completely waterproofed capillaries to more and more and smaller and smaller unwaterproofable capilliaries.

Now some predictions can be made. The small unwaterproofed capillaries will hold more water than the large waterproofed capillaries because the latter refuse to hold any water at all. Certainly the equilibrium water pickup will increase with beating on sized sheets.

The extra water in the sheet will wet and decrease the strength of more fiber to fiber contacts. Presumably the tensile strength of a sized sheet, on immersion in water, will deteriorate faster the more the pulp is beaten or fibrillated.

The extra water in the sheet also indicates more total area of water-carrying capillaries available for the transportation of water. Therefore, strange as it may seem, the liquid water permeability of the highly-beaten sized sheet may be actually greater than that of the loose texture, lightly-beaten sized sheet.

Although there are more capillaries they are of smaller diameter in the highly-beaten sheet. A water penetration test tells when the first trace of water gets through the sheet. Although a million capillaries will carry more water they won't get the first trace through the sheet any faster than a single capillary. Since the capillaries are smaller on the highly-beaten sheet the first trace of water will take longer or the water penetration test will be higher in spite of the fact that the permeability or area of the total number of water-filled capillaries is greater.

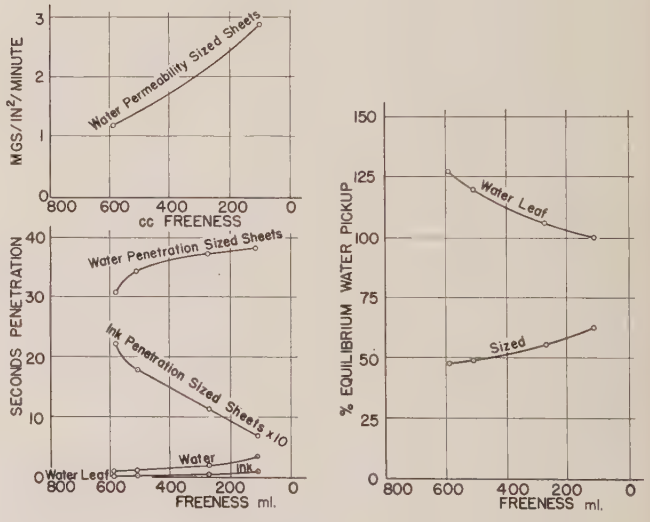

Fig. 2

If the hypothesis that small fibrils are unsizable is correct, it should be found that:

1. Equilibrium water pickup should decrease with beating on waterleaf sheets and increase with beating on sized sheets.

2. The liquid water permeability should decrease with beating on waterleaf sheets and increase with beating on sized sheets.

3. The wet break test should increase with beating on waterleaf sheets and decrease with beating on sized sheets.

4. The water penetration test should increase with beating on both waterleaf and sized sheets.

In other words, beating should show diametrically opposite effects on waterleaf and sized sheets by each test except the water penetration test. No prediction is made regarding the ink penetration test.

Figure 2 contains all the sizing tests for the same sheets as shown in Fig. 1. The tests are plotted against freeness and each type of test, and whether it is on waterleaf or sized sheets is plainly indicated. It is, of course, impossible to put the wet break data on this figure. However, it is easy to remember that the wet break test increased with beating on the waterleaf sheets and decreased with beating on the sized sheets. This decrease with beating to the increase in the number of unsizable fibrils and a consequent increase in the water-absorbing ability of the highly-beaten sheets was explained. Note that as predicted the equilibrium water pickup has changed from a decrease with beating on the waterleaf sheets to an increase with beating on the sized sheets.

The water permeability of waterleaf sheets is too high to be readily measured by the method used, but as predicted, the water permeability of sized sheets increases on the less open sheets because the larger holes are easily plugged with air while the small holes are unpluggable. As predicted, the water penetration test assumes its anomalous position of contradicting all the other tests because it depends upon the size and not the number of capillaries. The ink penetration test seemingly checks the other tests and runs contrary to the water penetration test. The ink penetration test really measures the ability of the ink dye to slip through the sheet without being coagulated or attached to the fibers. The greater water permeability of highly-beaten sized sheets possibly takes more ink past rosin deficient fibrils which are therefore low in coagulating power. However, ink liquid, from a free energy standpoint, is not water and it is very dangerous to assume that both would follow the same path.

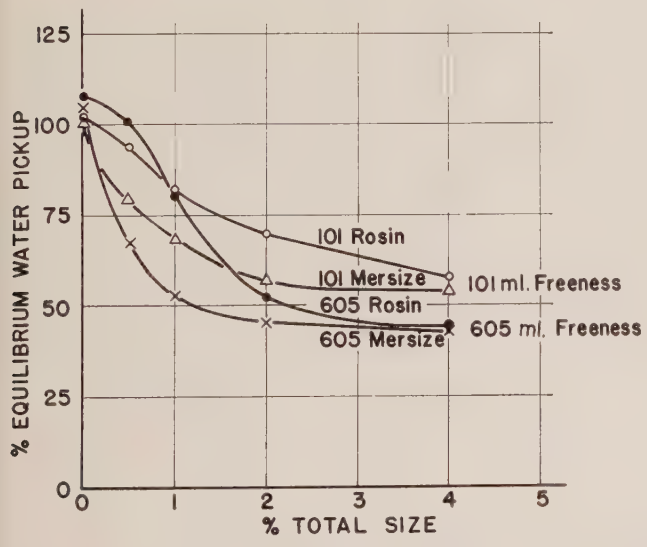

Fig. 3

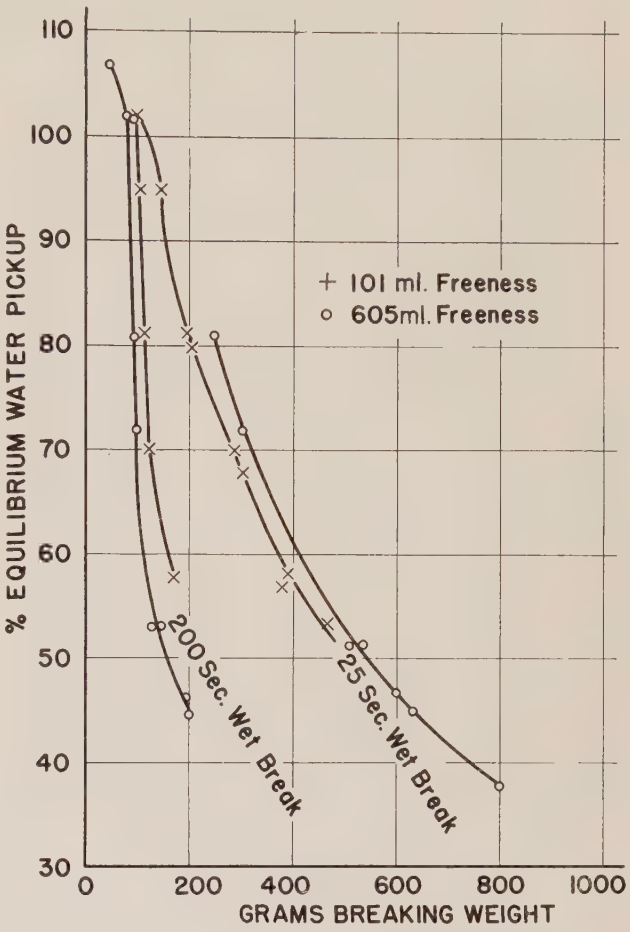

Fig. 4

A second series of experiments was run with the same pulp. Only two freenesses were used, a highly-beaten and a lightly-beaten sample. Each freeness was made into a series of sheets containing varying amounts of rosin and another series containing the same amounts of total size but consisting of a mixture of one-third Mersize and two-thirds regular rosin size. Waterleaf sheets were made from the same pulp.

The varying amounts of total size were used to see how much size was required to move the wet break line of the lightly-beaten sample to the right and beyond the wet break line of the highly-beaten waterleaf sheet. A half of one per cent rosin did not cause the lightly-beaten pulp to surpass the highly-beaten pulp but 1% rosin did make the lines cross. At 2% rosin, the coarse pulp was appreciably ahead of the fine.

It is reasonably certain that Mersize particles are only about half the size of rosin particles. Mersize was used to see if the smaller particles showed up better on the more highly-beaten pulp. No such effect was noticed. This really doesn't prove anything because the Mersize particles are probably still many times larger than the fibrils as indicated by the electron microscope.

Figure 3 shows the equilibrium water pickup plotted against the per cent size used for the four series of sheets mentioned above. Obviously 101-ml. freeness pulp holds more water than the 605-ml. freeness pulp at large dosages of size. This appears as if some of the water in the equilibrium water pickup lies between the tiny unsizable fibrils. The author had previously supposed all this water was inside the fibers. If some water is between the tiny unsizable fibrils it answers the question, "If the exteriors of the fibers are truly hydrophobic, how does water get inside the fibers?" The wicking of water through these unsizable fibrils to the interior of the fibers would seem a logical answer.

Figure 4 shows the breaking weight plotted against the equilibrium water pickup for the four series of sheets. Crosses represent the 101-ml. freeness sheets and circles the 605-ml. freeness sheets. There are two pairs of curves. One pair represents the breaking weight on 25-second immersion, the other pair after 200-second immersion. There are several points worth noticing on these curves. There is evidently a very intimate relationship between the wet break and the equilibrium water pickup or it wouldn't be possible to obtain the curves. The highest sizing occurs on the points nearest the bottom of the figure. Obviously, from the slope of the curves, the wet break test is much more sensitive to hard sizing than the equilibrium water pickup. It has previously been shown that the water penetration test is practically useless as a measure of hard sizing. At the short (25-second) immersion time the circles are all to the right of the crosses. That is for any given equilibrium water pickup the lightly-beaten pulp has the greater wet strength. On the 200-second immersions the circles are all to the left of the crosses. That is, the highly-beaten pulps possess the greatest wet strength. Attention was called to the likelihood of this happening (i.e., lines crossing) when Fig. (1) was discussed.

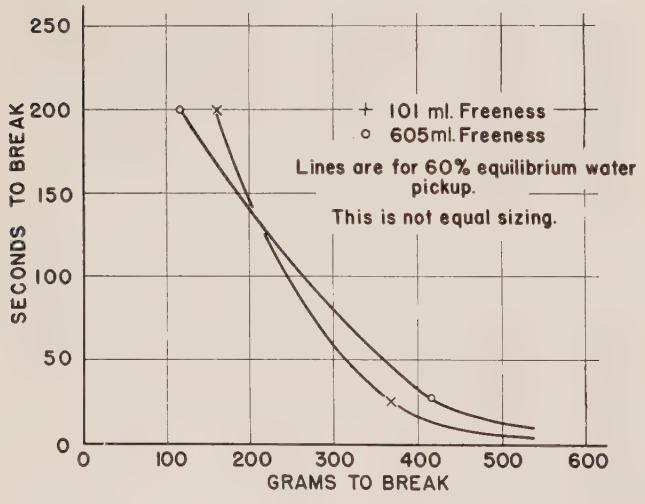

Fig. 5

Equal equilibrium water pickup for two different freenesses do not represent equal sizing, unfortunately, because although the amount of water is the same in each case, it is placed differently in the sheet. However, the curves illustrate a peculiarity of the wet break test that has to be taken into consideration. Figure 5 shows the wet break curves for two freenesses, each freeness having a 60% equilibrium water pickup. Obviously sizing swings the lower part of the curves to the right to a much greater extent than the upper or long time part of the curves. In other words, sizing is shown up by the lower and right hand end of the wet break curves. The upper and left hand part of the curves seems representative of the innate ability of fibers themselves to give high-tensile strength.

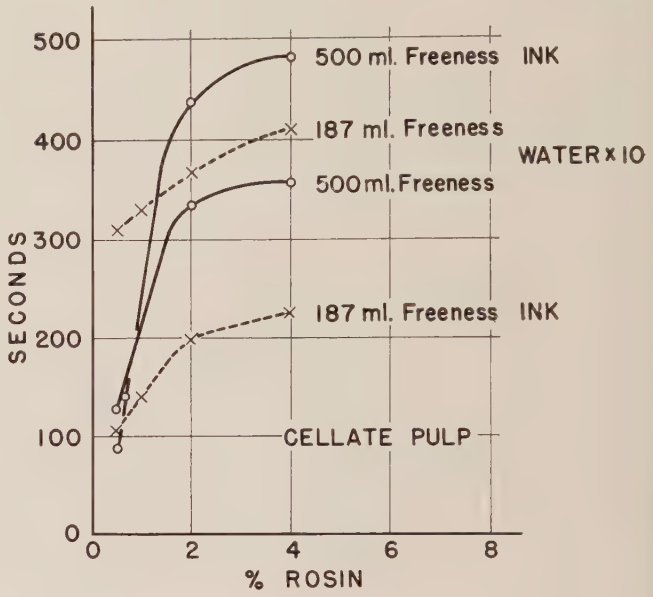

Fig. 6

Figure 6 is introduced just to show that ink and water penetration, running in opposite directions, is not peculiar to the sulphite pulp alone. Notice that at practically any dosage of rosin the lightly-beaten pulp shows the higher-ink penetration and the lower-water penetration test. There is no essential difference in the retained rosin at the high-sized end of the curves.

Equilibrium water pickups at high-rosin dosage were made on sulphite, cellate, and alpha pulps with the following results:

Pulp	*Lightly beaten*	*Highly beaten*	*Difference*
Sulphite	45	57.5	12.5%
Cellate	46	54.0	8.0%
Alpha	47	52.0	5.0%

It would appear from the above that on beating, pulps fibrillate in the order of sulphite, cellate, alpha.

It would seem to be likely that more such data might prove illuminating as to the way various pulps beat on the same machine and how different machines affect the same pulp. One might even obtain some leads as to the fundamentals involved in paper tensile strength.

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REPORTS AND DISCUSSIONS

Presented at National and Regional Conferences

Stock Flow in Pipes Round Table

Ed.—The following detailed report of the discussion that took place, during the Third Engineering Conference of the Pulp and Paper Industry at Buffalo, N. Y., on October 25–28, 1948, has been held up for publication until this issue of *Tappi* to provide a basis for a continuation of the discussion at the Fourth Engineering Conference to be held at the Statler Hotel, Boston, Mass., on October 31–November 3, 1949.

On Wednesday afternoon, October 27, the Engineering Research and Machine Design Committee held a round table discussion on the subject "Flow of Paper Stock in Pipes." Philip H. Goldsmith acted as moderator and was assisted by a panel of representatives of the leading pump manufacturers. These included John H. Hall of the DeLaval Steam Turbine Company, Tany Agronin of Shartle Brothers Machine Company, V. de P. Gerbereux of Worthington Pump & Machinery Corporation, Frank R. Forrest of Allis-Chalmers Manufacturing Company and George V. Shaw of Ingersoll-Rand Company.

Mr. Goldsmith opened the meeting, welcoming the listeners and guests, explaining the reason for the meeting and outlining the steps leading to the round table discussion.

Mr. Goldsmith: It was decided in a meeting of the committee that the first step in our consideration of paper stock flow in pipes should be to approach the leading pump manufacturers in the paper industry to ascertain from them what the basic information is that is available today and what the general attitude would be toward comparing and attempting to correlate the large amount of information which is available. With every discussion which we have had, it has become more and more clear that there seems to be a universal interest today in reviewing this whole subject. I believe on the part of the hydraulic specialists in the industry, as represented by the manufacturers of pumps and hydraulic equipment, by the plant engineers and by the leading researchers in the industry. You will see from this program that we are attempting this afternoon to appraise this whole situation. I am not going to introduce this subject because we have been fortunate in obtaining Col. H. Wyatt Johnston of Sutherland Refiners Ltd., who will open our discussion.

Col. Johnston: Mr. Chairman and Gentlemen—Around me I see a great many people who know a great deal more about the friction of paper stock than I do, so possibly you might be interested as to why I started this thing. I am afraid I am responsible to Mr. Macdonald and Mr. Hemphill in dumping this on the engineering research committee. But being interested in refiners, I was rather interested in the way the stock flowed through them, because sometimes it went through very fast, and sometimes it didn't go through very fast, and therefore, some means of evaluating that friction, or frictional resistance, or viscosity, or whatever you would like to call it, seemed to be very useful. So digging into the literature, I found a number of leading pump manufacturers had compiled much information and from the information published, we tried to see what the laws are governing the flow of paper stock.

I tried to get a lot of this stuff and put it together on a somewhat comparable basis and it struck me that we were touching something there which was of interest not only to the manufacturer of pumps, but to anybody who moves stock in any way, whether you move stock through a screen, through a riffler, or whether you put it into a head box or float it over a wire to the paper machine, we seem to know very little about the flow of paper stock, and some of the data which I tried to compare, was rather conflicting and I have tabulated some of the data and showed it to Mr. Macdonald and Mr. Hemphill and they felt it was something engineering research should take on.

Today we are primarily interested in the flow of paper stock in pipes, but we have hold of, as your Chairman said, a tiger by the tail. We are perhaps the only industry that handles millions of gallons of fluid and yet know very little about the properties of that fluid which is handled every day. It, therefore, seems that by sharing that information and extending that information we are going to get something which will be of value not only to the pump maker but to the paper machine maker and the paper maker as well. I believe, bearing in mind the first precept of the introduction, that I should introduce to you someone who really knows considerable about pulp and flow of suspension. I want to introduce Dr. Galley of the E. B. Eddy Company, of Hull. I had the privilege of listening to Dr. Galley about two years ago at the summer meeting of the technical section.

Mr. Goldsmith: Thank you, Col. Johnston. We are indeed fortunate in having Dr. Galley of the E. B. Eddy Company, who will give us some specific remarks on this subject, which should precede any discussion on this subject.

Viscosity of Fibrous Suspensions

W. GALLAY

THE MEASUREMENT of the resistance to flow of pulp stocks in pipes is of considerable importance to the pulp and paper industry and machinery manufacturers. Such measurements are ordinarily readily carried out, requiring only the measurement of the loss in head over any given flow path. It must be realized however, that the nature of the flow of such fibrous suspensions is extremely complicated and very little fundamental information is available on this problem. The axial ratio of the pulp fibers, the degree of fibrillation, the size and the degree of dispersity

W. GALLAY, Research Consultant, The E. B. Eddy Co., Hull, Que.

in size of the fibers, the flexibility of the fibers, are some of the factors which have a very important bearing on the resistance to flow of the pulp stock. Very small changes in consistency, such as might be considered negligible in mill operations, may have a very important effect in resistance to flow, particularly at higher ranges of consistencies. Frequently, two or more properties may change simultaneously, with the net effect of no alteration in resistance to flow. Thus two pulps of quite different properties may show similar viscosity characteristics. It is essential to have a full realization of the complexity of the problem in order that data of resistance to flow of pulp suspensions as measured may be correctly interpreted and correlated. Toward this end, it is proposed to initiate this discussion by reviewing some basic generalities governing flow of fluids.

Viscosity may be defined as the resistance of a fluid when subjected to a stress or deforming force. Aside from special wall effects, viscosity may be regarded as the internal friction in the fluid. Work must be performed on a fluid in order to maintain a shearing stress between planes of the fluid and bring about a flow against the internal friction, and this work is represented by the pressure gradient which is applied.

This viscosity is affected by a number of factors which are related to the properties of the liquid medium and particles which are dissolved or suspended in it. Some of these relationships have been developed theoretically on a hydrodynamic basis, and empirical relationships have been presented for the more complicated systems.

A considerable amount of literature is available in this field, but for the purpose of this discussion no attempt will be made at a systematic or complete review. A brief summary only is presented of some generalizations of major importance.

NEWTONIAN FLOW AND ABERRATIONS

In ordinary liquids, e.g., water, glycerin, alcohol etc., and in solutions of small molecules, e.g., inorganic salts in water, the viscosity is related to flow and shearing stress by the following basic classical law of Hagen-Poiseuille:

$$V = \frac{kP}{\eta}$$

where V is the volume of flow, P is the pressure gradient or shearing stress, η is the viscosity of the liquid and k is a constant involving the dimensions of the apparatus used for measurement. With such fluids, this law of Hagen-Poiseuille is obeyed over the whole range of shearing stresses up to the onset of turbulence, and over a very wide range of concentration of solute in solutions of small molecules. Since the viscosity is a constant, characteristic of the liquid involved,

$$V = kP,$$

i.e., the volume of flow is directly proportional to the applied pressure gradient (Fig. 1, graph 1). In such ideal systems, the viscosity of the fluid is independent of the rate of shear up to the onset of turbulence (Fig. 3, graph 1). There are two principal types of deviations from this basic relationship. One involves the presence of a structure resulting from some form of interaction among the particles in suspension. This is frequently encountered in commonly used systems and the tendency toward a solid structure when the system is at rest is termed thixotropy. A definite force is required to disrupt this structure prior to flow, and this initial force is usually termed the yield value. If the system shows Newtonian flow following the disruption of the structure, the viscosity relationship may then be represented by

$$V = y + kP$$

(*continued on page 56 A*)

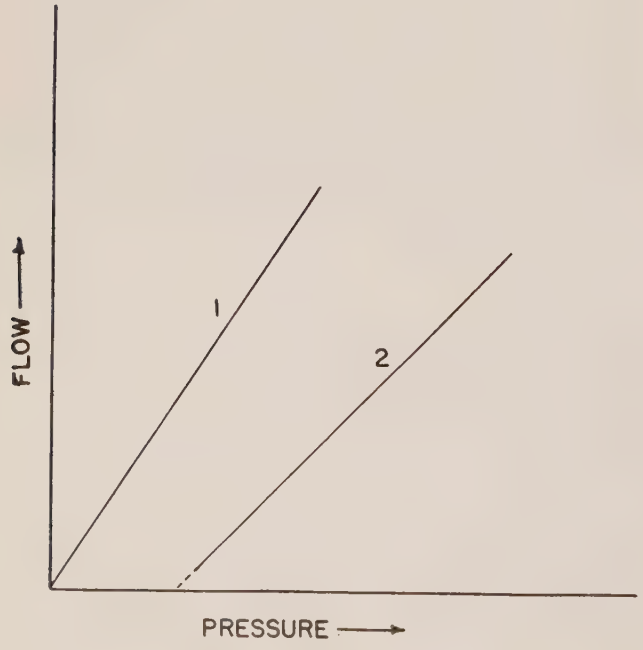

Fig. 1

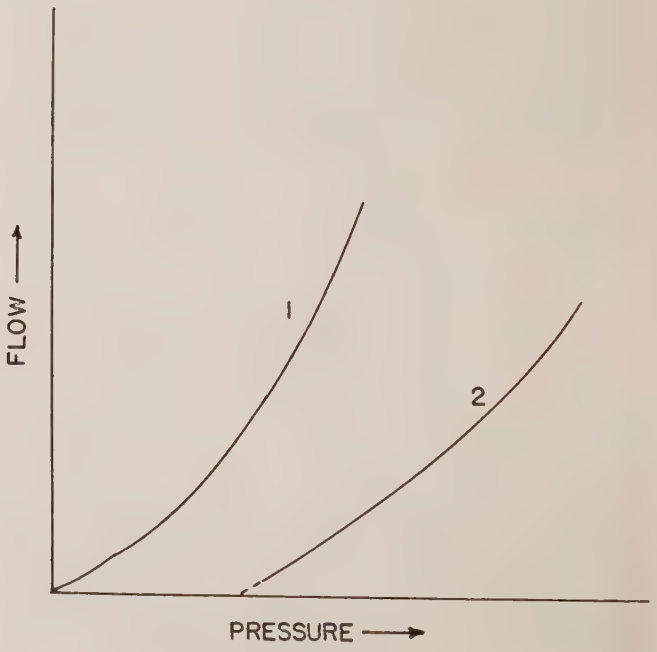

Fig. 2

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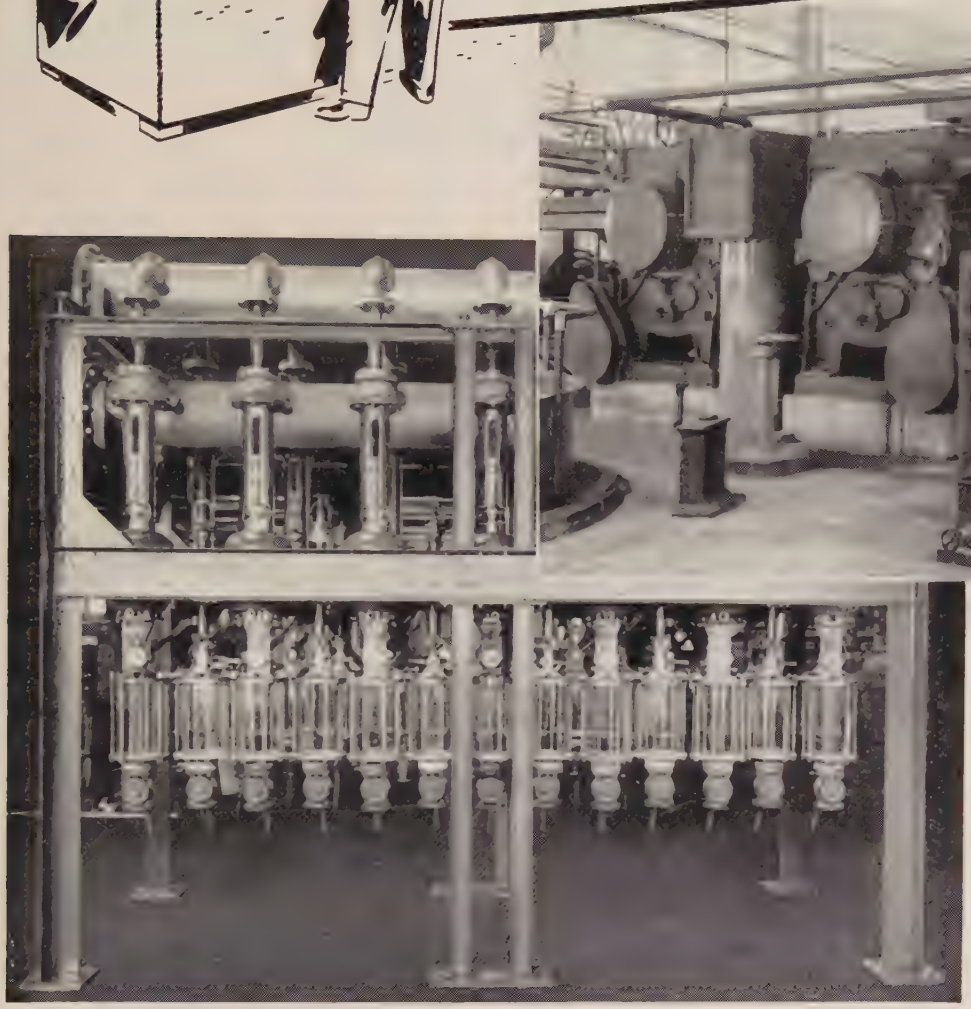

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(continued from page 54 A)

where y is the yield value (Fig. 1, graph 2). It is rather difficult to determine the exact relationships at very low values of V, and the linear function may not actually extend entirely to the abscissa.

Another important type of deviation is shown in all cases of solutions of linear molecules of high-molecular weight, e.g., gelatin in water or cellulose acetate in acetone. As a result of numerous points of free rotation within the molecule and of thermal motion, it is reasonably certain that such compounds assume a coiled-up form rather than a rigid rod shape. Such solutions deviate from Newtonian flow down to very low concentrations, above which a form of interference among the dissolved particles affects the flow-pressure relationship. For certain solutes of very high-molecular weight, it has been shown that deviation from Newtonian flow occurs at concentrations as low as 0.2%. In such systems, the viscosity decreases markedly with increased shearing stress, presumably as a result of an orienting effect of the increased shear on molecules or portions of molecules of the solute. The volume of flow therefore increases with increased shear at a rate greater than that for linear proportion. Many expressions have been shown for this relationship, but a reasonable approximation is given by the following exponential equation

$$V = kP^n$$

where n is an exponent greater than 1 (Fig. 2, graph 1). With such fluids, the viscosity decreases from a relatively high value at low rates of shear to a minimum value at higher rates of shear. The shape of this curve depends on the physical characteristics of the solute (Fig. 3, graph 2). In some instances, it would appear that a structure followed by an orientation effect is possible and the combined relationship would then be (Fig. 2, graph 2)

$$V = y + kP^n$$

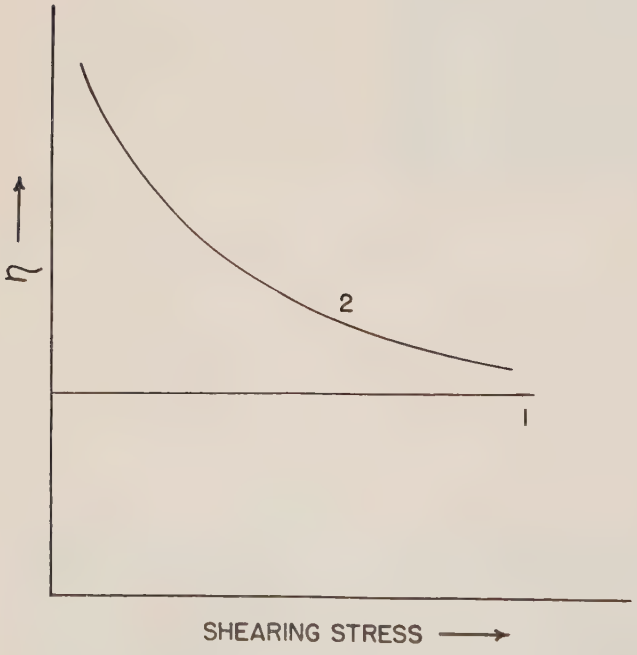

Fig. 3

EFFECT OF CONCENTRATION

A basic relationship in viscosity was derived many years ago by Einstein on purely theoretical grounds, for suspensions of spherical particles of small size in low concentrations. The relationship is

$$\eta_{sp} = 2.5c$$

where η_{sp} is the specific viscosity of the solute, i.e., the relative viscosity of the suspension minus 1, and c is the concentration. This equation has been experimentally tested in a number of systems and has been found to hold well over a limited range of concentration.

For higher concentrations of relatively spherical suspensoids, i.e., with an axial ratio of 1, the linear relationship no longer holds. A number of equations have been shown to represent experimental data, all of which include expressions containing higher powers of the concentration, e.g.,

$$\eta_{sp} = 2.5c + 14.1c^2$$

It is apparent therefore that in suspensions, the concentration factor in flow-pressure relationships must be taken carefully into account, since the pressure gradient required to produce a given flow is governed by the specific viscosity of the suspended material.

EFFECT OF AXIAL RATIO

It is apparent, where we are dealing with non-spherical suspensoids, that the shape of the particles must be taken into account, on the basis of their increased resistance to flow. This shape factor is most simply represented by the term F, denoting the form of the suspended particle, and, in the case of a fiber, numerically equal to the ratio of length to diameter.

The original equation of Einstein then becomes $\eta_{sp} = 2.5Fc$, where $F = 1$ for spherical particles.

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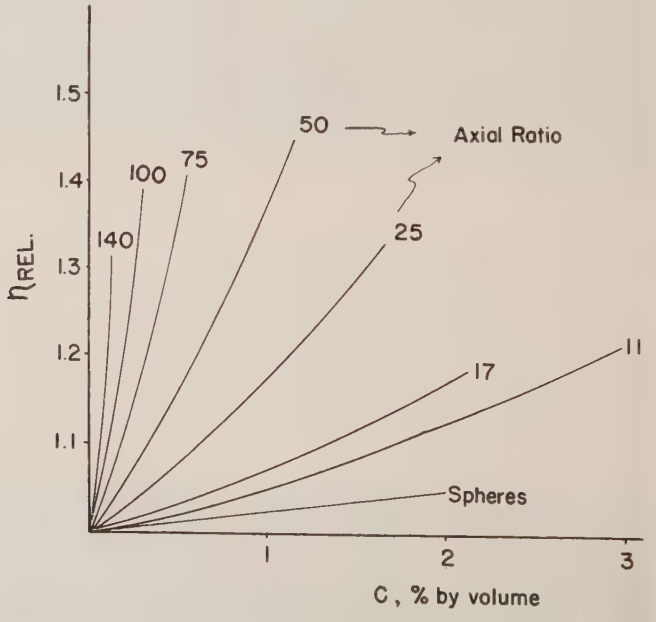

Fig. 4

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(continued from page 56 A)

Where F reaches higher values, this linear relationship no longer holds and terms containing higher powers of F must be introduced to take into account the effect of the shape of the particles. It will be noted that this is superimposed on the concentration factor, and higher powers of both F and c must normally be taken into account in the viscosity of fibrous systems. A great many empirical relationships have been derived for such systems, of which one is shown as an example taken from the work of Eirich, found for one specific system:

$$\eta_{sp} = 2.5Fc + 8F^2c^2 + 40F^3c^3$$

In general, there is obtained a viscosity-concentration curve which is convex to the concentration axis, and the degree of convexity depends on the axial ratio of the fiber under consideration.

VISCOSITY OF PULP SUSPENSIONS

Pulp suspensions involve suspended fibers of very high axial ratios, of the order of 50 or greater. It is apparent therefore that the flow of such suspensions will be non-Newtonian down to very low concentrations. At all concentrations commonly encountered in the transportation of pulp in mill practice, where a resistance to flow of pulp is under consideration, the flow-pressure and viscosity-concentration relationships among others will not be linear. In addition, the fibers are not rigid rods, but possess a degree of flexibility and plasticity which will have an appreciable effect. The particular property of the fiber surface which, on drying, will be responsible for bonding to a neighboring fiber, may also be reasonably expected to have an effect on resistance to flow even in dilute suspensions. In higher consistencies, the high-axial ratio will undoubtedly lead to a structure which requires added shearing stress for flow, and at very high consistencies, the suspension may show such high resistance to break-down of structure as to produce plug flow, or flow as a continuous or semicontinuous structure. The varying effects encountered in beating, e.g., fibrillation, chopping, surface changes, etc. may be expected to have enormous effects on the flow properties of the stock, and all are familiar with the difficulties involved in relating such beating effects within one mill, let alone through the industry generally.

Figure 4 (taken from the work of Eirich) shows schematically a group of curves representing the relationship between the relative viscosity and concentration for suspensions of rods of varying axial ratios in a liquid. The curves are strikingly similar to those shown by solutions of organic polymers of different molecular weights. With higher axial ratios, the viscosity rises very steeply with the concentration. These data were obtained in a torsional viscosimeter using models of smooth-surfaced synthetic fibers of specific lengths and the same diameter. It may be definitely assumed, with pulp suspensions having considerably increased specific surface that even steeper rise of viscosity with concentration would be obtained. It is noted therefore that in the range of axial ratios and specific surface encountered in pulp suspensions, the slope of the viscosity-concentration curve is extremely steep. Very minor changes in concentration (e.g., of the order of a few hundredths of 1%) will result in very large changes in viscosity in such suspensions.

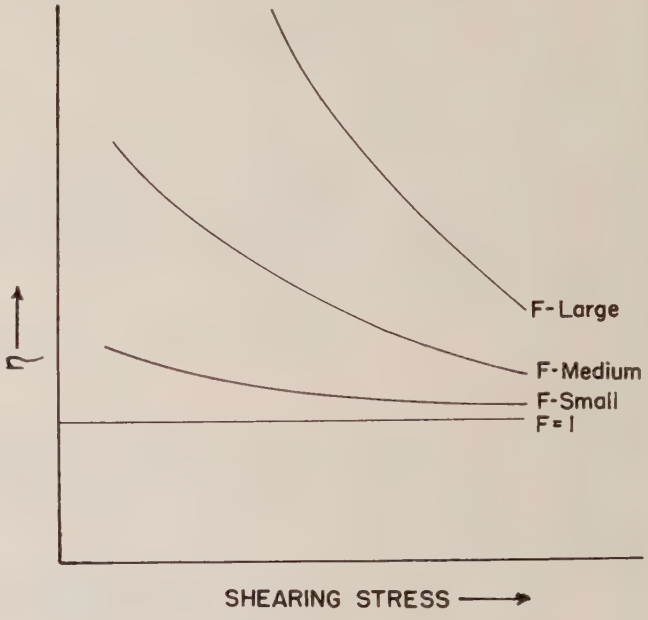

Fig. 5

Figure 5 shows schematically probable relationships between viscosity and shearing stress in suspensions containing fibers of various axial ratios at one arbitrary concentration. With pulp suspensions, the viscosity or resistance to flow will be extremely high at low rates of shear, and the viscosity will decrease rapidly to a minimum at high shearing stresses. This dependency of resistance to flow on rate of shear will increase with pulp consistency. It is noted therefore that measurements of resistance to flow of such suspensions must take into account very strictly and quite precisely the rate of shear at which such measurements were made.

The problems of wall effects and effects of nonlinear flow paths, e.g., elbows, valve gates, etc. are further complications which will not be discussed for the present purpose.

It is emphasized therefore that the relationships involved in the measurement of the resistance of pulp suspensions to flow are involved ones. It would not appear feasible at this stage of development of the subject to set up useful generalizations derived on a theoretical basis. Empirical relationships, obtained under carefully controlled conditions, should be derived for a number of pulp systems, and such data confirmed or related to mill data. It is probable that useful engineering data would be obtained in a careful systematic investigation of this nature.

Received July 12, 1949. Presented during a discussion on the flow of paper stock in pipes held at the Third Engineering Conference, Hotel Staler, Buffalo, N. Y., Oct. 25 28, 1948.

(continued on page 60 A)

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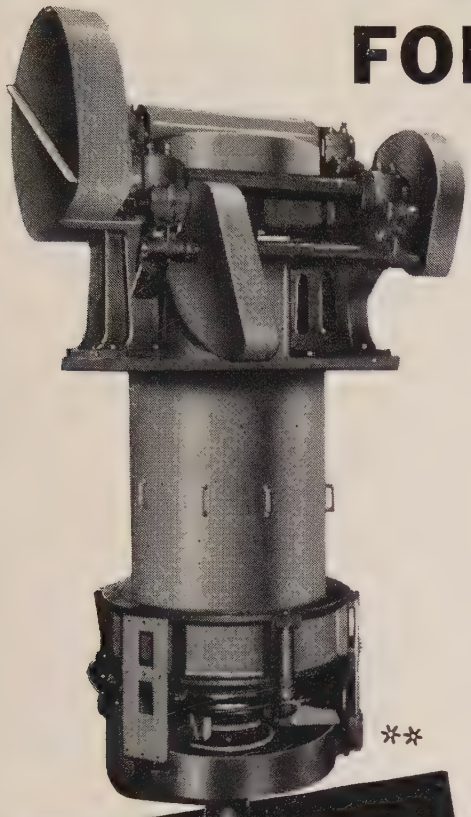

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(*continued from page 58 A*)

Mr. Goldsmith: Thank you, Dr. Galley. For the first time in my life I have an understanding what is meant by that little word "viscosity." I think it is a very important aspect to keep in mind during our discussion.

You will notice there is a panel up here with me of representatives of leading concerns in the manufacture of pumps who are participating here in the sense of a panel of experts to try to answer any questions. This has been so suggestive and stimulating on Dr. Galley's part, I want to take a moment here to ask whether or not there are any immediate questions you would like to ask. We are going to spend about an hour and a half to try to cover quickly what is known today about the flow of paper stock in pipes, before we devote a complete hour to discussion. A little discussion after each presentation would be worthwhile in order to fully understand the implications raised by the speakers.

Question: You spoke of fiber length as one of the principal factors in changes of viscosity. Is the ability of the fibers to absorb or give off water, or in other words "freeness," a factor in this formula or is that something else?

Dr. Galley: All the various factors which contribute to freeness would certainly have a bearing on it. Every characteristic of the sort of thing which you feel in a handful of pulp when you take it out of the beater, the wetness and so on, is going to affect it. When I spoke about length, I meant not only length, but everytime you get fibrillation or hairs on the fiber, that's all going to form a part of the internal friction. I draw on length particularly because I know of molecule length in analogous fields that you can draw on. I don't know of any field that one can draw on when one talks of the effects of fibrillation but obviously that is going to have a tremendous effect. Talking about viscosity one should not think altogether of the fibers as such, one should think about the amount of free water that is there, because it is that water that has got to flow. You do not actually have any flow within the fiber, you've got to have flow between the fibers. Therefore, the amount of free water is very important. With more and more fibrillation you encompass more and more water and leave less free water to flow, and in addition you get entanglement among the fibers themselves. Both of those factors are very important. In answer to that question, which I think is a very important one, I think that every factor that goes into freeness as we know it, will affect the story.

Question: Would you say, Dr. Galley, that this conception of viscosity of a stock, of a specific stock, is a necessary part of the description of that stock? In other words, dealing with this problem, we realize that we have a large number of different kinds of paper stock. In order to obtain information of practical value, it will be necessary to be able to define the particular stock for which any information is presented. Is the conception of viscosity, Dr. Galley, an essential part? Could you define stocks and differentiate between them without this concept of viscosity?

Answer: In answer to that question, I do not think you could, on a really intelligent basis. You could get many empirical facts but you would always be running into properties of stocks about which you knew nothing.

I venture to say offhand if you had a ready way of measuring this integer, so that you could fit that particular unknown stock into that equation, you would know what you need to know about that from the point of view of flow. It may be in two stocks A and B you have certain characteristics in A which would tend in one direction and certain characteristics in B which would tend in another direction and those would compliment each other from the point of view of the equation. Actually, from the engineering point of view, I think you are not interested in that. You are trying to integrate all types of stock, short fiber, long fiber, more or less defined and so on into as small a compass as possible so that you will be able to predict what sort of flow you will get. Therefore the pipe diameter, the amount of loss of head you need and so on. It seems to me that you must arrive at some sort of basic information of this kind in order to do the job right. I will admit that in order to do this a number of typical stocks over a range will have to be examined. I think on the basis of that you can arrive at a relative simplification of this kind, which will really tell you what you want to know about the subject.

Mr. Goldsmith: Thank you, Dr. Galley. I would like at this time to call on the next speaker who is presenting a specific case of work done in his mill. It is not necessary to introduce K. J. Mackenzie of Eastman Kodak Company. We ask Mr. Mackenzie to come forward and present his report.

Mr. Mackenzie: Gentlemen, what I have to offer you may be considered as salt, pepper, and onion going into this stew which we have.

For some time we have been conscious of the fact that pump manufacturers were supplying us with pumps that had appreciable greater capacity than asked for, also recommending motors that were frequently twice the size necessary to handle the quantities we planned to pump.

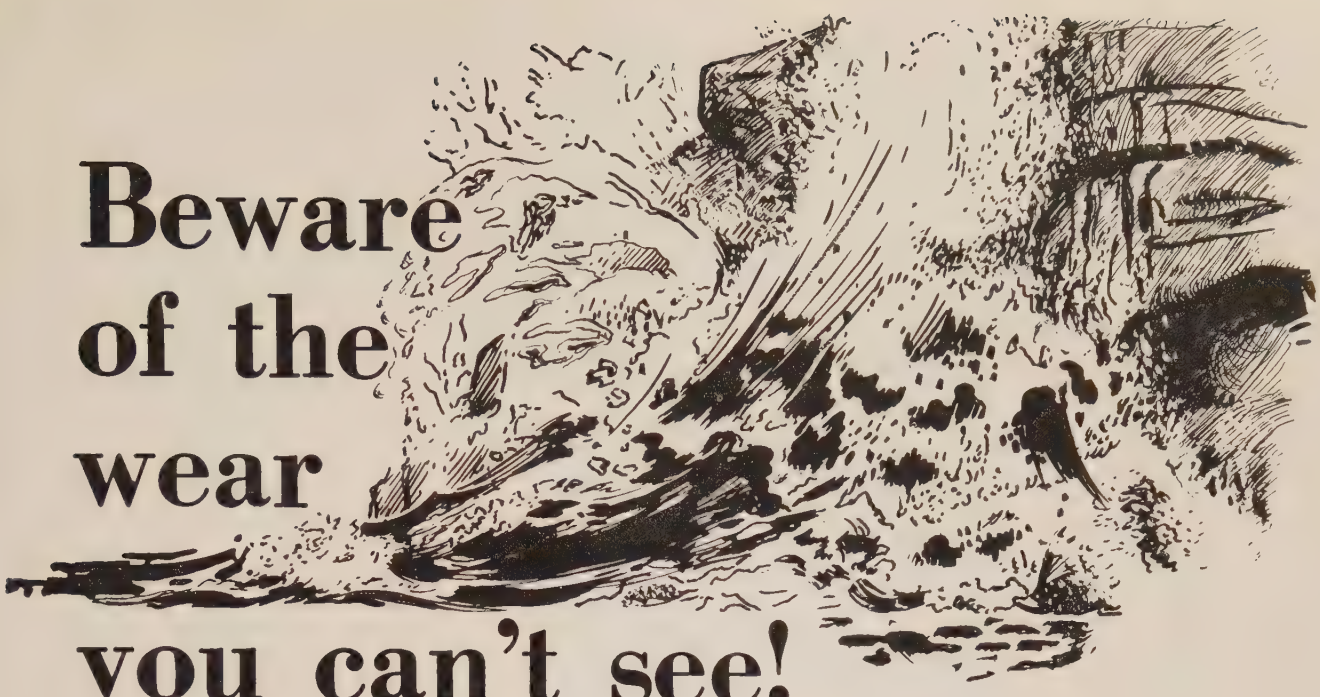
Because most of our stock lines are 4-, 5-, and 6-inch copper tubing, there were not any friction loss curves available from which we could check the pump manufacturer's recommendation. For this reason we prepared curves from studies made on our existing stock lines, using the conventional methods of installing pressure gages in straight runs and collecting the discharge in calibrated tanks.

One curve showed a comparison of 4-, 5-, and 6-inch pipes with the various consistencies. The second curve showed the two curves from the first curve for 6-inch pipes at 5 and 6% consistency, compared with 4% consistency in 6-inch spiral riveted pipe from the Cameron curves. It was noted that the curve for the spiral riveted pipe from Cameron data for 4% falls between 5 and 6% on our curves. From our data it would appear that 4% should lay appreciably to the right of the 5% curve, giving a much lower value for head loss than that given in the Cameron Handbook.

A few weeks before this meeting we noticed a peculiar phenomena in the paper mill that I believe has a very pertinent bearing on the subject under discussion today. In tracing down some peculiar conditions on our paper machine, one of our engineers noticed that two different furnishes of stock varied quite radically in their action in a Dilts hydrapulper. The rate of agitation was appreciably greater for one than for the other. In order to confirm this we had some stock broken up and added to a Valley beater. Referring to Table I, the two pulps were Nos. 1 and 4, and the first test made was at the 3% consistency. You will note in Column 2 under Circulation Rate that pulp No. 4 traveled 22.5 inches in the Valley beater in 5.5 seconds, whereas pulp No. 1 took 16 seconds to travel the same distance. These pulps are two high-alpha sulphites made to the same specifications, having similar maximum, minimum, and average fiber lengths and very similar slowness characteristics. The only difference we know of between them is that the west coast fiber has a larger diameter than the east coast fiber. This would indicate that it will be impossible to get pulp friction curves that mean anything unless we very carefully define all of the characteristics of the fiber on which the tests are run.

When this information was obtained we decided it would be advisable to check some other pulps in order to have some additional information for this meeting and as a

(*continued on page 62 A*)



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(*continued from page 60 A*)

result the other pulps listed on Table I were checked in the same manner. We found it necessary to cut down the consistency to get circulation on some of these other pulps so two sets of tests were run, one at 2.5% and one at 3%. As this work was done rather hurriedly the results cannot be compared between the 2.5% consistency and the 3% consistency. You will note, comparing pulps Nos. 5 and 6 that there is an appreciable difference between the flow rate of northeastern unbleached sulphate and that of Swedish unbleached sulphate. Pulps Nos. 8 and 9 give a comparison between east coast and west coast bleached sulphite. These

Table I

Pulp	Geography	Cook	Type	Consistency[a] (1)	Consistency[a] (2)	Circulation rate (1)	Circulation rate (2)
1	East	Bleached sulphite	Alpha	2.5	3.0	8.3	16
2	East	Bleached sulphite	Alpha	2.5	3.0	Barely moving	22
3	East	Bleached sulphate	Alpha	2.5	3.0	9.3	25
4	West	Bleached sulphite	Alpha	2.5	3.0	5.7	5½
5	East	Unbleached sulphate	Regular	2.5	3.0	7.1	Barely moving
6	Sweden	Unbleached sulphate	Regular	2.5	3.0	3	Barely moving
7	West	Unbleached sulphate	Regular	2.5	3.0	4.8	6.4
8	East	Bleached sulphite	Regular	2.5	3.0	10.3	8.7
9	West	Bleached sulphite	Regular	2.5	3.0	3.6	5¼
10	East	.....	Regular	2.5	3.0	2	9.7

[a] Seconds to travel 22.5 inches in beater by floating cork.
(1) 2.5% consistency with no weights on bed plate lever arm. (2) 3% consistency with 5316 grams total weight on bed plate lever arm.

two pulps would be considered very comparable for papermaking characteristics, yet the circulation rates are appreciably different.

These other pulps confirm the conclusion arrived at with respect to the two alphas; that is, that in talking of friction resistance to flow in pipes, we cannot just talk of ground wood, sulphite, and kraft. We will have to develop curves for typical pulps and then develop factors for the variables that may exist in that particular type of pulp and, as is evident from the attached table, the variation between pulps in a definite class may possibly be greater than the variation between any two individual pulps in different classes.

Mr. Goldsmith: Thank you, Mac. You have given us an example of the investigation made in a mill, and actual facts bearing on this major problem. It would seem to me that your tabulation would be right in line with Dr. Galley's previous remark. It appeared to me that the shorter stock appeared to be the ones with the shortest circulating time, and the longer fibers seem to show the longer circulating time. Am I right about that?

Answer: No, the only difference in the two, which I talked about at first, that we know of, is diameter of fiber. The average minimum and maximum fiber length is exactly the same.

Question: Did the larger diameter fibers give the shorter time?

Answer: Yes.

Dr. Galley: Of course if you had fibers which were larger in diameter, at least for a given consistency, you would have fewer fibers. Of course that would have a tremendous bearing on the number of fibers, I think if those were analyzed, perhaps mathematically, you might find that difference was large enough to give you that difference in flow.

Mr. Goldsmith: Mac, when you spoke of fiber length, didn't you mean proportionate length to diameter? If you had larger diameter fibers, it would be very likely the length to diameter would be lower. I noticed that groundwood, for instance, had a very short circulating time on your chart.

It could be, Mac, that everything you have just presented is closely related to the remarks which Dr. Galley has made.

Question: On the diagram of the Valley beaters, some stocks circulated faster at 3% and some circulated faster at 2.5%. I wonder if that doesn't show a little doubt about the method of circulation, because following Dr. Galley's paper, higher concentration definitely means higher viscosity and consequently lower circulation rate?

Mr. Mackenzie: The only thing I can say to that is that the consistencies were accurately determined. The stock was broken up in a "Lightnin" mixer and then put into the Valley beater with the roll up. The roll was in the same position at all times, the circulation rate was obtained only by the energy from the roll in the beater. They were all done within two or three days so that any variation due to wear of the knives in the beater which would cut down the effective diameter of the roll was eliminated.

This was not an accurate theoretical study at all. It has all been done in the last month. It just happened to hit at a time when I was thinking of coming up here. When I saw the results from the two alphas, I thought I would get some more information from some of the others to see what they showed.

Question: You have been using an expression which I think by definition perhaps should be early in an investigation, and that is the friction on the sides and bottom of the beater. I believe it is true that the internal friction of the fiber against fiber is also a major cause of rise of pipe friction. I wondered if the two should not be separated right at the start. Is there some arbitrary means of separation so that we are dealing with two different types of friction, one at the surface and one internal friction? I think if the two are taken together you are going to get a series of variables that are going to be conflicting.

Mr. Goldsmith: Mr. Agronin has just whispered to me that that question is later answered or at least touched upon in a paper which Dr. Van den Akker was good enough to send to this committee for presentation today, so we will be hearing about it a little later. Your question points to it directly.

Question: I would like to ask Mr. Mackenzie a question—length of time of circulation—all the stocks that were tested, were they all circulated about the same amount or were some circulated for longer periods than others, or just how?

Mr. Mackenzie: They were broken up with a laboratory instrument equivalent to a "Lightnin" mixer and were immediately put into a beater and as soon as it steadied down, measured. I would say the total time elapsing was about five minutes. Incidentally, these were all dried pulps, they had been previously dried and were different than slush pulps. They were all broken up well before testing.

Mr. Agronin: I believe it was brought out in the first curve; the reference to copper pipe and steel pipe. That

(*continued on page 64 A*)

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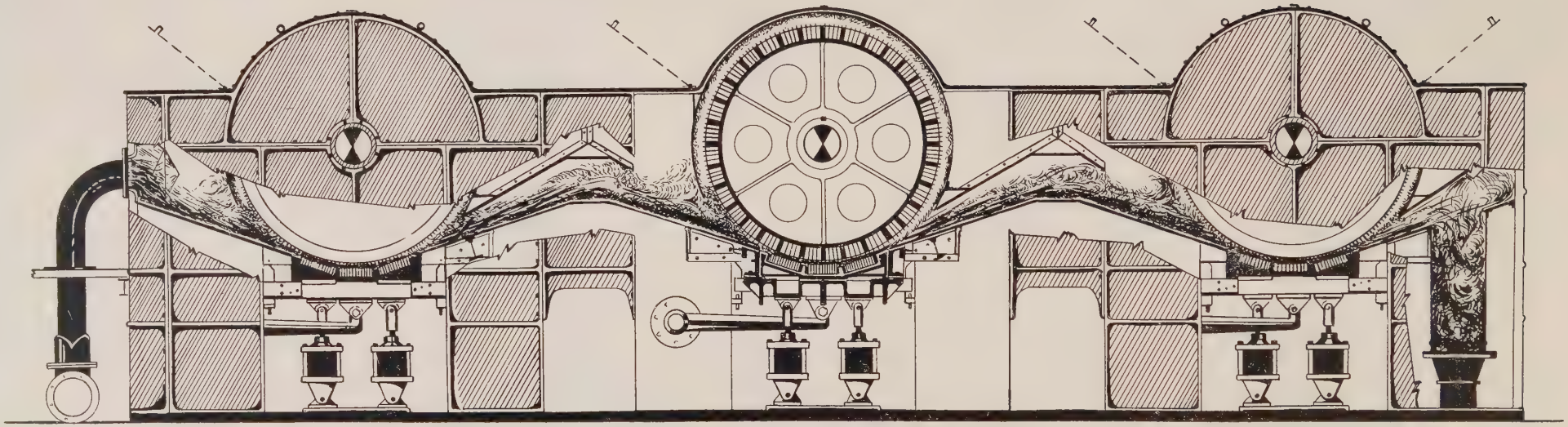

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(continued from page 62 A)

is something which we more or less take into consideration in figuring pumps. We use a factor of about 75 to 80% of your cast-iron figure, figuring C is 100. I was just wondering if you took 75%, how close to that curve that you got would it check with the other curve. Roughly, it looks very close, I mean the curve is proportionate all the way down. It looks rather interesting.

Mr. Goldsmith: In other words, you are saying, Tany, that the Cameron curve that Mac had shown would appear to be higher than Mac's curve for 5 and 6% stock, when it should have been lower, in other words, it should have been over to the left. At the same time, Mac's work was in tubing and the Cameron curves have been taken in steel pipes. I believe that was very close to what we have. This brings out one of the other basic factors which needs to be considered, namely, the nature of the pipes in any study of this sort.

Col. Johnston: I have just one point here that might be interesting to show that these things apply to other operations than pulping. A number of years ago a certain company in Canada which has two paper mills using many different woods, black spruce with a density of 0.4 to 0.42 and balsam with a density of 0.32 to 0.33, put some screens in the black spruce mill. They worked very well so they put new screens in the other mill. They ran them at the same consistency on groundwood which was ground to about the same freeness and same fiber length distribution. To their surprise when the screens went to function their capacity was only about three-fourths on the low density wood. The problem at this time was drawn to my attention and after thinking it over I found that when you multiply the screen capacity by the corresponding density factor, they will agree very well, and that ties in with your line of reasoning about the larger fiber diameters and possibly of fiber wall thickness.

Mr. Goldsmith: Incidentally, Col. Johnston, I think you have brought out another important aspect to this question, and that is, while we have today specifically limited our discussion in order to be able to arrive at some conclusion, we have limited it to the flow of paper stock in pipes, nevertheless, this subject in its implication is bound to go into most of the process steps in the paper industry. I think your remarks have brought out the fact that what we learn is a first step in understanding a more accurate use in hydraulic facts in our engineering work in the mill in general.

Question: I would like to ask if the temperature of the stock is taken into consideration.

Mr. Mackenzie: The only thing I can say on that is that water was used at 70° in breaking up the stock and work was done at room temperature, not in an air conditioned but a controlled temperature area.

Comment: The only temperature change which might occur would be due to the work that you are putting into the beater itself and that will affect the friction loss to a large extent, the friction of the fiber.

Mr. Mackenzie: I think that may be true on the unbleached sulphites and on the kraft. On the high alphas, they require a great amount of energy to change their hydration characteristics very much and I doubt very much if there is any effect there.

Mr. Goldsmith: I would like to take a moment to introduce the panel. At the furthest left is John Hall of the DeLaval Company; beside me on my left is Mr. Forrest of Allis-Chalmers; on my right is Tany Agronin of Shartle Brothers, and next to him is George Shaw of Ingersoll-Rand, and Mr. Gerbereux of Worthington.

The next three men are to talk on the friction curves with which we are most familiar. When most of us came into the industry, we were reaching for the Cameron handbook if we wanted to know whether a pump was going to be big enough for the duty, and the next speaker will present the history and origin of those curves. It will be followed by a presentation of the friction curves used by Allis-Chalmers which have gained wide use, and lastly, those you call the Hayton curves, I believe originally assembled by J. E. Bond, so that of the three papers, let me introduce George B. Shaw of the Ingersoll-Rand Company, who will tell us a little something about the history and origin of the Cameron curves.

Mr. Shaw: On behalf of the Ingersoll-Rand Company, I wish to extend to the TAPPI Engineering Research and Machine Design Committee the Company's appreciation for the invitation to participate in this conference. We had our initiation into the fraternity of stock pump builders in 1922 when we furnished the pumps for the Three Rivers Mill of the International Paper Company in Canada. On that job the pumping conditions, head, and capacity were clearly set forth in the specifications by the customer's engineers so that a knowledge of friction losses due to the flow of stock through pipes was not too essential to us in making successful pump applications.

Once we were in the business of building stock pumps we soon learned that the pump engineer was obliged to equip himself with a knowledge of stock handling problems equal to that of the paper mill engineer, and in many cases we found ourselves to be consulting engineers in addition to being pump builders. The average mill superintendent in those days did not possess data to figure head losses in pipes so that it became our problem to supply that information.

Having no facilities for making such tests we turned to our friends in the paper industry for assistance. Mr. White, then Chief Engineer of the International Paper Company, was good enough to present us with a series of curves that had been worked out by W. J. Trimbey as a result of tests he had made at their Bureau of Tests at Glens Falls, N. Y., along about 1907.

At the time we came into possession of these curves there was little data available on this subject, but since the International Paper Company had used them with success it was our feeling that we could also get along with them until such time as something better was developed. By applying safety factors gained by experience we have gotten along very well with these curves for years without the development of serious trouble.

As represented to us, the tests on which these curves were based were made with air-dried sulphite and groundwood stock using 6-, 8-, 10-, 12-, and 16-inch spiral riveted pipe. The flow of the stock was with the laps in the pipe.

Other tests were run using cast-iron pipe in some of the sizes. Such comment as we found on the original curves indicated that the loss through the iron pipe was only slightly less than in the case of spiral-riveted pipe.

It was also found that with the stocks as then tested that there was so little difference between the losses due to flow of sulphite and groundwood that the curves could be used for either. Insofar as sulphite and kraft stocks are concerned we have always increased the values shown on the curves by 10%.

While we have gone along with the Trimbey curves all these years, we feel quite confident that much better data could be worked out at this time for the general use of the industry, and from among the paper mill engineers present at this convention I am sure that we could enlist plenty of help.

There are marked differences between the Trimbey curves and those published by Allis-Chalmers, Gould, and Shartle Bros. which would make it appear that one could arrive at most any answer depending on the curves used. I suspect

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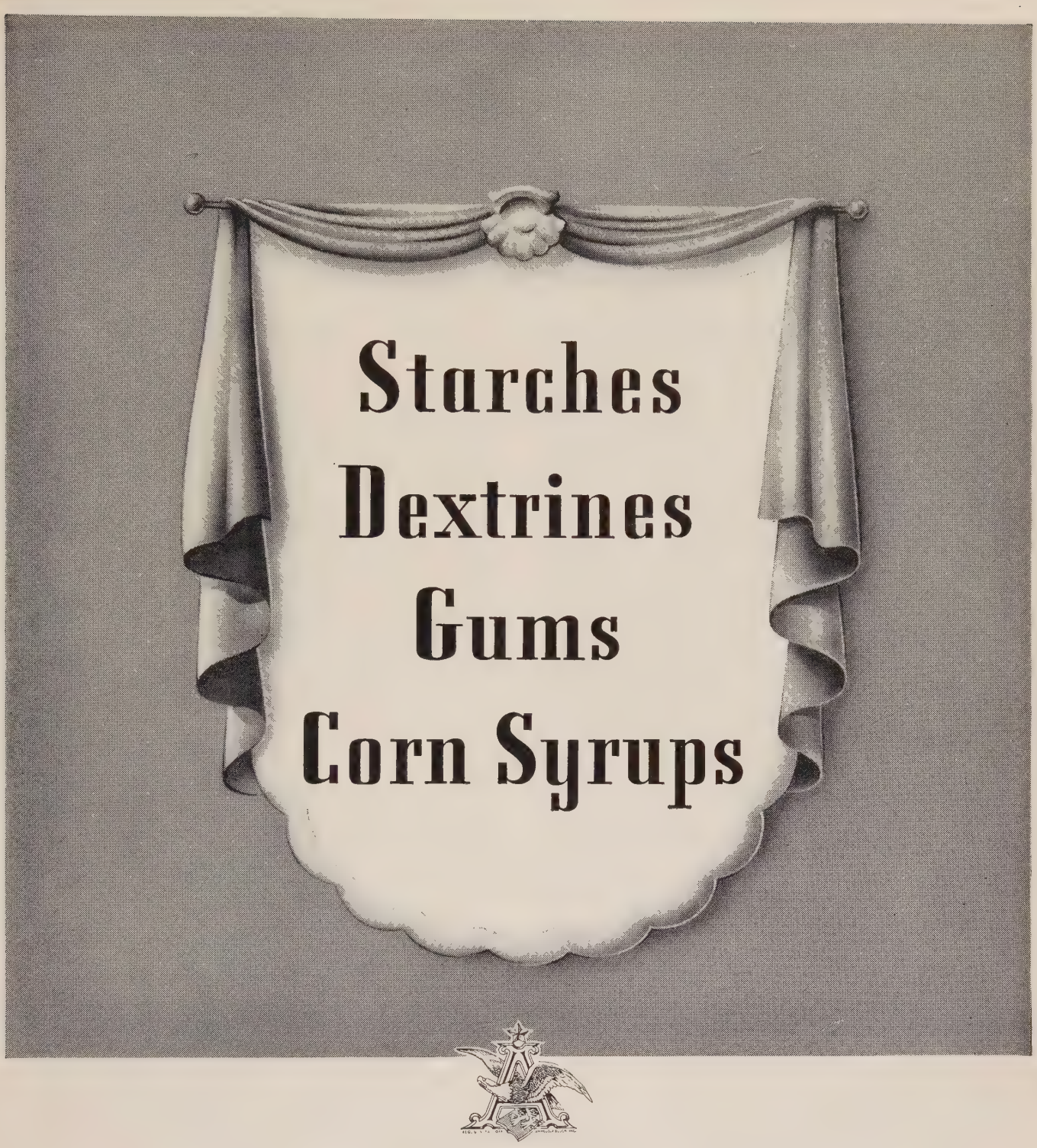

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(continued on page 64 A)

that this will be brought out by Mr. Agronin later in this discussion.

We are of the opinion that the time has arrived to give the matter of stock friction-loss further study and to prepare reliable standard curves which can be used by all mills and pump manufacturers alike. I realize this is an undertaking of major proportions when one considers the wide variety of stocks handled and the different kinds and sizes of pipe used in paper mills today. Such a program should be possible of accomplishment, if the interested mills and pump companies will cooperate in this effort, working with the Engineering Division of the Technical Association.

As far as Ingersoll-Rand is concerned, we will be glad to enter into such a research program and stand the expense of that part of the work to which we are assigned by the committee, such as furnishing a suitable pump, the services of a test engineer, or both. While such tests are being made the pump losses could also be scrutinized and the effects of friction losses noted on the head, capacity, and efficiency with varying consistencies of stock as compared with the original performance of the pump when handling water.

Our company has made some scattered tests along this line on groundwood and sulphite, and while the data obtained enable us to predict with some accuracy how a pump will perform when handling stock, the tests were not conclusive enough for publication.

F. R. Forrest: The Allis-Chalmers Manufacturing Company friction data show the actual test results, of sulphite and groundwood stock flowing through iron pipes of various sizes.

These tests were conducted at the Abitibi Power and Paper Company, located at Iroquis Fall, Ont., in 1927. Over 100 complete test runs were made requiring approximately three months for completion. A supply of stock was taken from the mill and pumped back and forth between two chests, a measurement of friction being taken between two definite test stations. This drop in pressure was determined by a water-flushed mercury manometer and the capacity being passed through the pipe was determined by volumetric measurement in one of the two chests. The stock was used over and over until a drop in freeness was noted, after which a new supply was taken from the mill. The 6-, 8-, 10-, and 12-inch iron pipe used for this test procedure was taken from the mill reserve and was extremely old and pitted, forming a very rough interior surface. It was thought at this time that the rougher the interior surface the higher the test results would be, thus, giving us safe estimating values for determining required heads, for future use. Since completion of these tests we have found that this is not true and that the smoother the pipe interior wall the higher the friction loss, especially on consistencies of 3% or over.

I have measured some 8% oven-dry consistency friction losses which fall below the friction of the 5% on iron pipe. I have also, in the next hour, measured it and it was extremely high, way up above the 5% level. Why it changes is what we would like to know. I spent considerable time at one of the northern Wisconsin mills trying to check friction losses on higher density, and in no case have I been able to make anything that even resembles the curve. I know the temperature affects it, freeness and working of the fiber, and also the vibration that exists in the pipe-line itself. The more you let the pipe-line shake around, the better results you have. If you anchor it down solid, your friction loss goes up, that much I know. That is why I am pretty sure that on an 8 or 9% stock the friction loss will fall down to as low as that equivalent to 4%. That can be seen readily at the discharge of the pipe itself. After you pass about 6 or 7% and your flow is coming out of the discharge opening, there is a film of water of possibly an eighth of an inch. This is absolutely pure water, and water which squirts in all directions and the solid core of stock is practically dry. There is just one more factor which we will have entered into before this is over.

Mr. Goldsmith: Gentlemen: I think it is becoming more and more apparent that the variables and factors which must be taken into account are being roughed out here by our speakers. Are there any questions that anyone would like to ask at this point briefly to either Mr. Shaw or Mr. Forrest?

Question: Mr. Shaw mentioned briefly that the original curves were based on flow in spiral piping with the flow in the direction of the laps or the shingle of the pipe. Do you have any rough idea as to relative friction loss in pipe hung that way and pipe hung in the opposite direction.

Mr. Shaw: No, we do not, the only tests were made when they were in that one direction as far as I know.

Question: Do you know whether or not that is a factor at all?

Mr. Shaw: Well, I suspect with that extra ridge it would develop a little extra head in the pipe. May I add one thing to what has been said. In laboratory experiments on measure of viscosity of very high concentrations or high consistencies, you often notice a considerable irregularity in that curve and if you use transparent pipe you can see change-overs sometimes from a more laminar type of flow to a plug type of flow and back again so that you get curves. I am not at all surprised that in practice you get widely varying results. Sometimes the friction appears to consist mainly of friction between planes in a fluid and at other times it consists of friction in one plane between something that is stuck on the wall, as it were and a solid plug in the middle or any degree in between those extremes.

Question: You raised the question of roughness of the pipe, do you get a better flow when you have a rough surface?

Mr. Forrest: Yes, that is absolutely true. We have had occasions to check the friction loss in copper pipe and it is approximately 40% higher than it was on a rough iron pipe and that pipe was put into the same pipe-line, handling the same stock. The only explanation that I can give for that is this: that due to the fact that your flow is nearly a streamline motion, just like a plug moving through the pipe, if the pipe is absolutely smooth, you get a fiber to metal contact at all times. If it is rough, you only hit the high points and you can try this yourself, if you put up a rough plate and a smooth plate and then put stock on there—the stock will stick to the smooth surface, but it will roll down the rough one—that bears that out.

Question: How about these stainless alloys where you get the high finish and wetting properties at the surface?

Mr. Forrest: We have never measured it, but I would say offhand that they probably would compare with the copper pipe. A wood-lined pipe is fairly high to start with but as it slimes, the friction becomes very low.

Question: Is it due to the wetting action that you get there?

Answer: It is due to the sliming action, yes, that is right.

Question: If you have a self-wetting surface, will you have the same effect that you get with slime?

Mr. Forrest: It is entirely possible, although I believe that if you have a fairly smooth surface, there is no tendency for a water film to be formed around the outer periphery of that pipe, unless you have roughness. If you have roughness it moves the fiber away from the pipe walls, so that it only hits the high points, and I think it was back a few years ago that there was some company on the west coast that put rifles in the pipe itself. Their claim, at that time, was that that reduced the friction due to the fact that they were just rifling the stock through. Well, they were partly right, it did reduce the friction, but the reason for it was they were jumping from one rifling up to the

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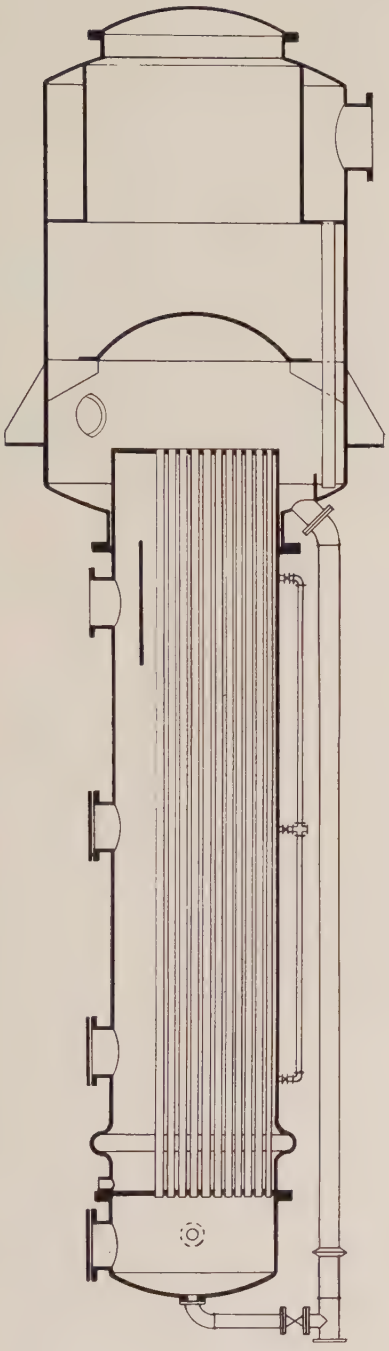

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(continued from page 66 A)

other when they had a water film in between the rifles. I think that is right.

Question: I think you brought out a point that I know of in one of the mills in New England where the Superintendent told me that when he wanted to get additional capacity out of his pumps where he had a copper pipe, he used to beat hell out of it with a ball-pean hammer and that had the effect of reducing the total head, and he did get additional capacity.

Question: Isn't that the same principle that is used in laying pipe, if you want to go from larger to smaller pipe or vice versa, you want to go in one step instead of using a reducing section?

Answer: Yes, that is true. If you are reducing from a large area to a small area through a taper reducer, you could have sort of a wedging action so that your water will tend to draw through the center core and thicken up at that point. A friction loss of the taper reducer is pretty close to four times what it would be if you would make this a 90 degree reduction.

Question: That is on stock?

Answer: That is right. That is about 4% stock or over.

Mr. Goldsmith: The more I hear about these peculiar aspects of this problem, the more I realize that the things we have taken for granted are not always true.

Question: I was talking to somebody in New England, about a year ago, and he was speaking also of the high-density stock and he said if you superimpose a large pressure on that stock, I don't mean a large pressure drop, but if you flow through a pipe and out through a valve and if you have a high pressure on the stock, you would greatly increase flow having the same pressure drop over the length of the pipe. Just putting a high-static pressure in that section would change your stock resistance materially, in that way you would be highly successful in pumping high-density stock.

Mr. Goldsmith: Gentlemen: With your permission we will go on to the next presentation. We are fortunate in having received a report from Dr. Van den Akker at the Institute of Paper Chemistry, although he cannot be here in person. Mr. Agronin of Shartle Bros. Machine Co. will present Mr. Van den Akker's comments which he sent to us.

Comments by J. A. Van den Akker

Mr. Agronin (reading Dr. Van den Akker's paper):

In an interesting discussion prepared for the annual meeting of TAPPI in New York in 1939, J. E. Bond and R. M. Bond (*1*) compared the data on the friction of flow of paper stock in pipes obtained over a period of years by T. R. Hayton, J. E. Bond, E. B. Morse, and R. M. Bond with those obtained by F. Forrest and G. A. H. Grierson (*2*) the latter having served as the basis for the charts published by the Allis-Chalmers Manufacturing Company. In that discussion the good point was made that one should not regard pipe-friction charts with "finality," in the sense that calculations based on the data will enable one to make an accurate calculation of the friction losses to be expected in any given layout. This is true, of course, irrespective of the care and accuracy of work in any given experimental run, in view of the differences in character of paper stock of nominally the same kind, of the differences in smoothness of the pipe wall, differences in the pipe material, and differences in the geometry of the layout. It was suggested that data from different sources might be compared more satisfactorily on the basis of the friction factor, for moving stock against solid surfaces, which had been developed for fundamental considerations (*3*) and utilized in laboratory work on frictional phenomena (*4*).

In the present discussion, the writer would like to offer some considerations relating to these two subjects. The first of these is the matter of variability of pipe friction data attributable to differences in layout, and the bearing of the latter on the accuracy of calculation of head loss for any given piping system. In the last of a series of three masters theses on the subject of friction between solid surfaces and paper stock, John L. Gray (*5*) developed laboratory equipment for the accurate measurement of friction for linear velocities up to about 20 feet per second. During the course of his work, Gray discovered a phenomenon that undoubtedly has an important bearing on pipe friction, particularly as the observed head loss in a pipe depends on the proximity to the inlet end of the pipe to elbows, pumps and other devices which would be expected to produce strong mixing of the stock. When the consistency of the stock (unbleached kraft) was greater than about 2%, a critical relative velocity between the solid surface and the paper stock could be observed. Below the critical speed, the relationship between friction and velocity was stable and accurately reproducible. However, for velocities above the critical speed, *two* relationships were found: (1) If the stock had been freshly agitated immediately prior to an observation of friction, the relationship was fairly linear, displaying uniformly increasing friction with increasing speed (see Fig. 7 of reference *5*). This has been designated the "instantaneous" relationship. (2) If the relative movement between the solid surface and the paper stock was permitted to go on for a number of seconds, it was observed that the friction fell by a substantial amount to a value which then remained steady. This has been designated as the "equilibrium" relationship. The drop in friction was much greater (many per cent) for smooth surfaces than for rough (see Fig. 9 of reference *5*). The critical velocity depended upon conditions, but was typically of the order of 10 to 15 feet per second. The transition from the "instantaneous" to the "equilibrium" relationship was associated with a visible balling up of the fibers in a narrow zone near the solid surface, and with movement of the balls of fibers with the solid surface.

It seems highly probable that these phenomena occur in a stock flowing in pipes, when the consistency is in the typical range of from a few to several per cent, and the linear velocity of flow is of the order of 10 feet per second. Under certain conditions, we can then expect to find that the head loss per foot length of pipe will be substantially greater in the first portion of pipe immediately following a centrifugal pump than in a later, long, straight course of the pipe. It is possible that conditions could be such in a particular layout that the region of the relatively high head loss to be expected in the first portion of pipe following a centrifugal pump could be many feet in length. If, on the other hand, the linear velocity or the consistency of the stock is low, these phenomena would be expected to play only a minor role.

The engineering implications of Gray's work are fairly obvious. Rules established for water on the location of the upstream manometer tap (a certain number of diameters distance from the nearest upstream elbow or other source of turburlence) would not hold for paper stock.

1. *Tech. Assoc. Papers* 22: 126–130 (1939).
2. Forrest, F., and Grierson, G. A. H., *Paper Trade J.* 92, No. 22: 39–41 (May 28, 1931); *Tech. Assoc. Papers* 14: 259–261 (1931).
3. Van den Akker, J. A., "Mechanics, Hydraulics, Heat and Thermodynamics." Appleton, The Institute of Paper Chemistry, 1941, 282 pp.
4. Baldwin, Paul C., and Van den Akker, J. A., *Paper Trade J.* 109, No. 12: 31–36 (Sept. 21, 1939); *Tech. Assoc. Papers* 22: 317–322 (1939).
5. Gray, John L., *Paper Trade J.* 118, No. 17: 29–34 (April 27, 1941).

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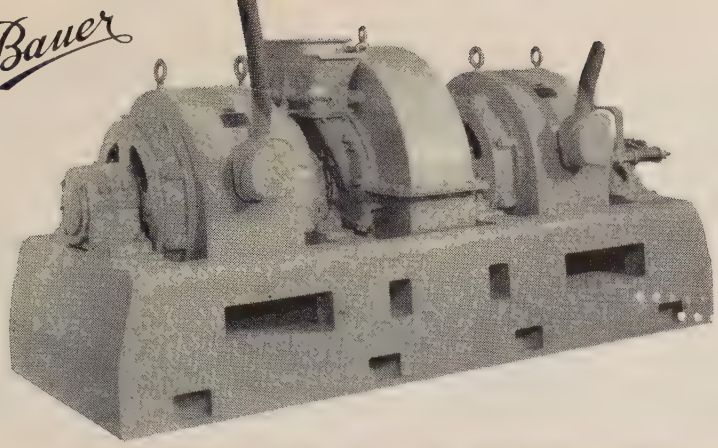

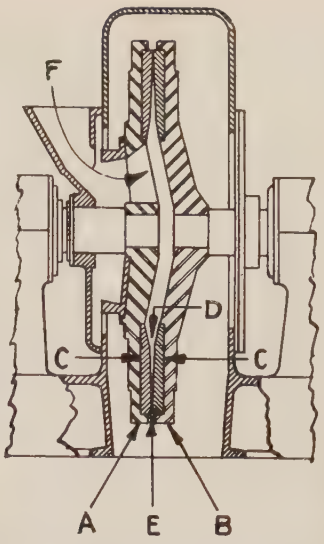

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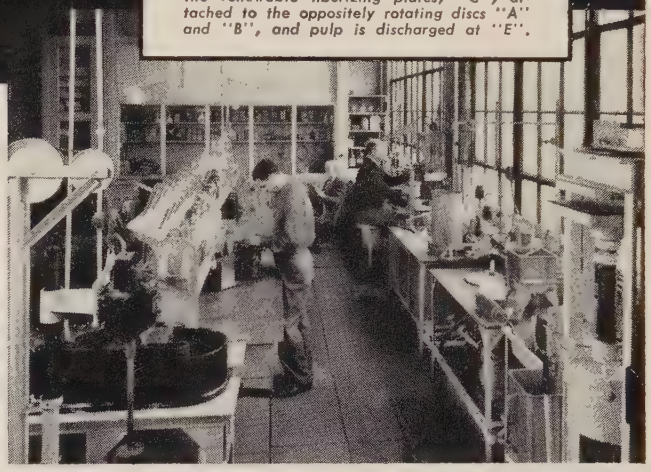

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(*continued from page 68 A*)

Geometrical differences in various experimental layouts would be expected to result in differences in stock friction data (at higher flow velocities and for consistencies above a few per cent), even though it might be possible for the various investigators to employ the same paper stock and the same quality of pipe. Similarly, one could not expect accurate agreement between calculations of head loss in a given installation for the handling of paper stock and the subsequently observed actual head loss. It would be of interest if, in future determinations of head loss, several manometer taps were to be employed, for example, two or three might be distributed immediately downstream from a pump to enable one to determine the head loss gradient in the first portion of a pipe, and another group of taps might be located at points near the downstream end of a long, straight course of the pipe to yield data on head loss for "equilibrium" flow.

The second subject on which the writer would like to comment is the possibility of rationalizing data on the friction of flow of paper stock in pipes. In the flow of any fluid through pipes, pressure drop can easily be translated into force, the force obtained being that occurring across the interface between the fluid and the wall of the pipe. In the flow of most fluids, the motion of the body of the fluid influences the surface friction, however, it is true in all cases of steady flow in straight pipes that the total force equivalent to a pressure drop acts across the interface between the fluid and the pipe wall. The laws of flow of water and other Newtonian fluids have been rather fully developed. Dimensional analysis has provided a means for rationalizing hydraulic data, the treatment of which would be very complicated, indeed, in the absence of such analysis. Attempts have been made to extend Reynolds' theory to the flow of paper stock, but any success that has been achieved has involved rather complex manipulations. The reason for this is found in the fact that paper stock does not have viscosity in the Newtonian sense, that is, frictional traction stress in paper stock is not proportional to the rate of shear. During a study of the problem a number of years ago, the use of a friction factor, analogous to that earlier developed by Sigurd Smith (*6*) in his study of the internal friction of stock moving against stock, suggested itself for use in studies of stock moving against a solid surface. This factor is simply the frictional stress, in pounds per square foot, acting across the interface between the stock and the wall. When this factor is called into play in the calculation of pipe friction, it is found that the head loss per 100 feet of pipe is $H = 400/wD$, where w is the weight of one cubic foot of stock, and D is the pipe diameter. Alternatively, if the head loss is known, $wDH/400 = HD/6.4$, if we take $w = 62.4$ pounds per cubic feet.

In their comparison of pipe friction data, J. E. Bond and R. M. Bond calculated values of the friction factor from the data of Hayton and of Forrest and Grierson. They included data on the friction factor obtained by Paul C. Baldwin (*4*), who developed the first of the rotary friction apparatuses employed in the studies at the Institute of Paper Chemistry. It is of interest to note that, in spite of the great differences between the geometries of equipment and kinds of movement of the stock in pipes and in the rotary instrument, the friction factors obtained with the latter equipment fell inside the ranges of values calculated from the pipe friction data. Further inspection of the friction factors calculated from pipe friction data reveals that is essentially a function only of consistency and linear velocity (for a given kind of stock), exhibiting only a small variation with pipe size. This is illustrated in the tabulations of calculated values of the friction factor (shown in Table A).

Table A

V *ft./sec*	D=*0.500 ft.*	D=*0.667 ft.*	D=*0.833 ft.*	D=*1.00 ft.*	D=*2.00 ft.*
Friction factor based on Hayton's data, in lb./sq. ft., for pipes of various diameters. Sulphite stock, 3%					
1	1.09	1.10	1.04	1.05	0.94
4	1.41	1.41	1.37	1.37	1.25
7	1.76	1.72	1.69	1.69	1.56
10	2.10	2.03	2.01	2.03	1.87
Friction factor based on Allis-Chalmers data. Sulphite stock, 3% and 4%					
8 (3%)	1.96	2.15	1.84	1.77	
8 (4%)	5.20	5.33	5.04	4.61	
Friction factor based on Allis-Chalmers data. Groundwood stock, 3% and 4%					
8 (3%)	1.96	2.22	1.91	1.95	
8 (4%)	4.49	4.99	4.01	3.90	

The friction factors based on the Allis-Chalmers data do not display as good an approach to independence of pipe diameter as those based on the Hayton data. This is not necessarily indicative of differences in accuracy of determination of head losses in the investigations of Hayton and of Forrest and Grierson, but might be indicative of the influence (discussed earlier) of geometry of the layout and of the effect of pumping on the nature of the stock. It is of interest to note that the friction factors computed on the basis of the Allis-Chalmers data for 8-inch pipe (0.667 foot) are incompatible with the friction factors for neighboring pipe sizes.

It appears that, for the purposes of estimation of head loss, perhaps estimation is the best that can be done in this area of work, one could obtain head loss for a given kind of pulp from a *single* chart. Such a chart would present the friction factor (plotted as ordinates) against linear velocity (plotted as abscissae), for given values of consistency. The head loss for 100 feet of pipe could then be obtained by computing $6.4/D$, in which D is expressed in feet. It is suggested that the engineers working in this field investigate the area of validity of the proposed chart, with particular reference to limitations on consistency and pipe size. In any event, it seems likely that the representation of data on the suggested basis will be of assistance in comparing the results of different workers, and in revealing sources of error which might otherwise remain hidden.

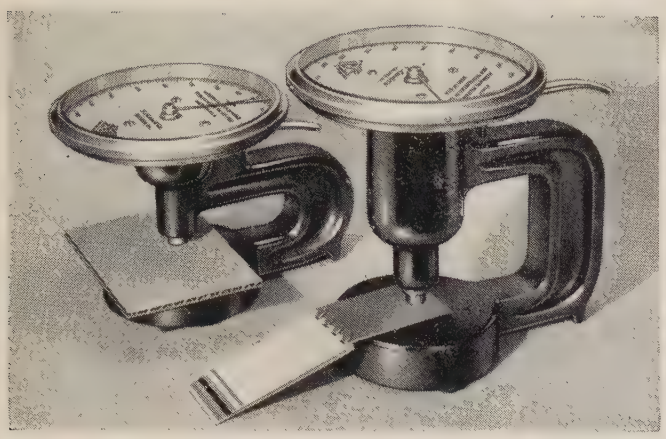
Mr. Agronin: In reading Dr. Van den Akker's paper, I find that he has calculated the friction factor per 100 feet of pipe for 3% stock (sulphite) based on 6-, 9-, 12-, and 24-inch pipe, at velocities ranging from 1 to 10 feet per second, and you will note in this chart that the correlation is fairly good. There are a few points in there where the correlation is off. He has also taken the Allis-Chalmers data and picked out (pointed out) 8 feet per second and there is also indication of friction loss. You will note that if you compare two curves and take the velocity between 7 and 10, 6-inch pipe, there is remarkable correlation. On 8-inch pipe there is no correlation and in 9- and 12-inch pipe the correlation is fairly obvious. Now, there is one point there on the 8-inch pipe that does not check up. He has counted on that to some extent.

Mr. Goldsmith: Thank you, Mr. Agronin. These last presentations were intended to give a rough blocking out of the type of information which today exists and which is the basis for all of our work in the mill. Unless there are

(*continued on page 72 A*)

6. Smith, Sigurd, "The Action of the Beater." Translated by R. Marx, London, The Technical Section of the Paper-makers' Association of Great Britain and Ireland, 1923.

CADY TESTING INSTRUMENTS ARE PRECISION BUILT FOR EXACT CHECKING AND COMPARING; WEIGHTS, STRUCTURES, THICKNESSES



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Either model equipped with 6″ diameter dial, glass covered, and graduated in $^1/_{100}$ths or half-thousandths inch. The Standard model measures up to $^5/_{16}$″ thickness, and is available with 4, 7, 12, or 18″ throat for calipering various areas of large size sheets. Dead Weight Model measures up to $^1/_2$″ thickness; has 4″ throat only. Cady Micrometers are in use throughout industry for accurate thickness calipering. Write for complete information and prices.

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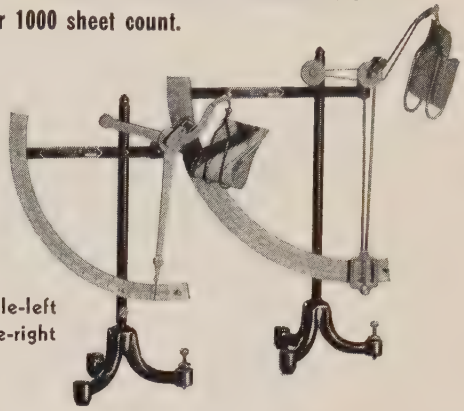

Tissue Scale-left
Paper Scale-right

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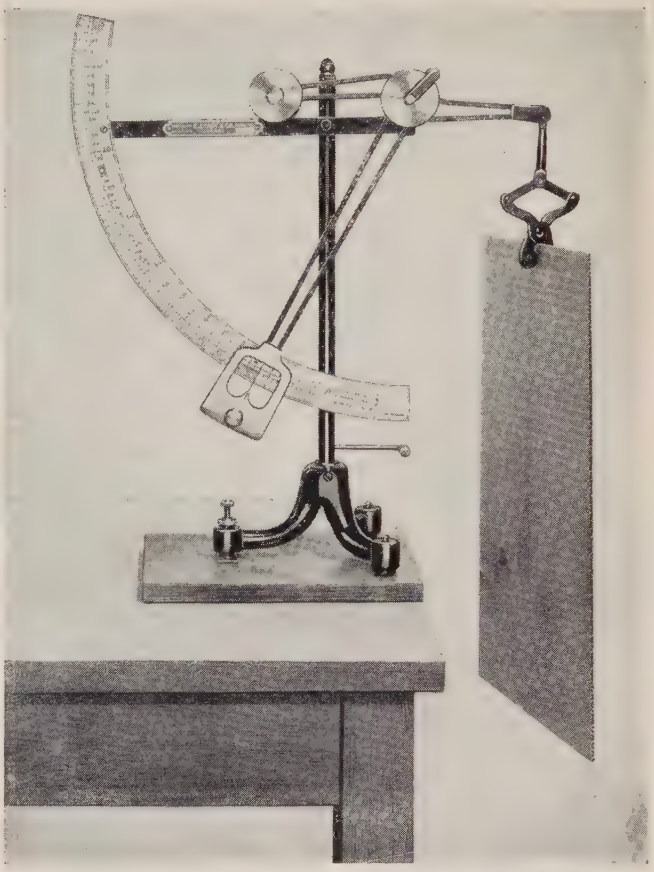

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(*continued from page 70 A*)

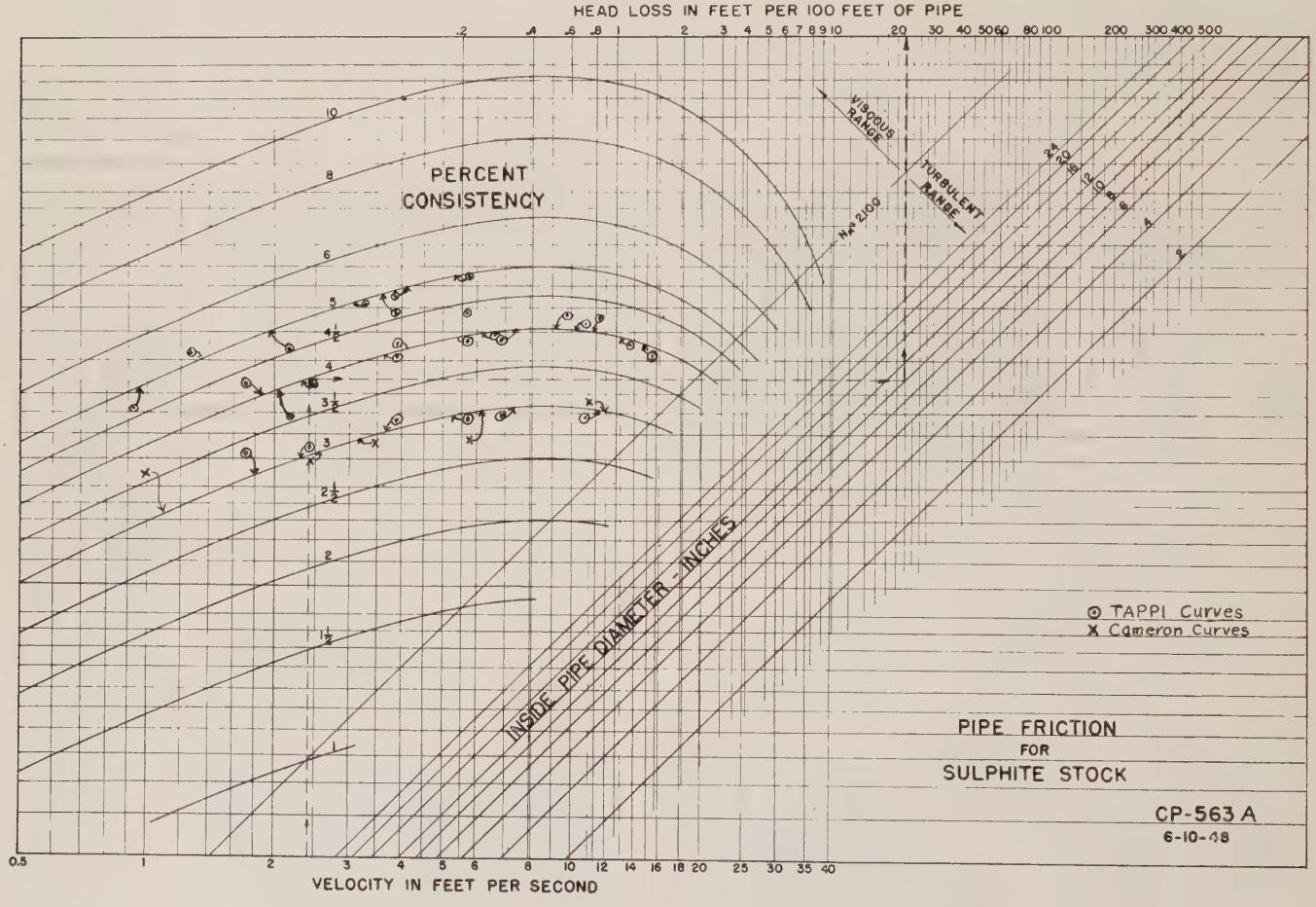
some pressing questions at this point, it might be well to go on to the last presentation of the afternoon in order to conserve as much time as possible for a discussion later.

Mr. Gerbereux of the Worthington Pump & Machinery Corporation is going to suggest to us a method of preparing pipe friction charts.

Mr. Gerbereux: The idea of preparing a chart and having a method of doing this with all these factors that have been brought up this afternoon, is kind of fantastic. However, we did do a little studying of this problem and we are inclined to believe that there can be some way in which we can get down to a chart which brings in a great many of these factors or perhaps a set of charts which brings them in.

Analyzing the Flow of Paper Stock Through Pipe

To approach the problem of determination of pressure drop of paper stock solutions flowing through pipe, it is desirable to consider some of the basic factors that are involved.


HEAD LOSS IN FEET PER 100 FEET OF PIPE
.2 .4 .6 .8 1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 80 100 200 300 400 500
PERCENT CONSISTENCY
VISCOUS RANGE
TURBULENT RANGE
N_r = 2100
INSIDE PIPE DIAMETER - INCHES
⊙ TAPPI Curves
X Cameron Curves
PIPE FRICTION
FOR
SULPHITE STOCK
CP-563 A
6-10-48
0.5 1 2 3 4 5 6 8 10 12 14 16 18 20 25 30 35 40
VELOCITY IN FEET PER SECOND

(1) All friction or head drop valves are dependent on the basic relation

$$\Delta H = f \frac{LU^2}{2Dg}$$

where

H = head in feet
L = length of pipe in feet
U = velocity in feet per second
D = pipe diameter in feet
g = acceleration due to gravity, feet per second
f = fraction factor determined from the Reynolds number friction factor relation
N_r = Reynolds number $= \frac{DUe}{M}$
e = density in pounds per cubic foot
M = viscosity in pounds per foot second
C = per cent consistency of stock

(2) Paper stock suspensions or pulps are not uniform (Newtonian) liquids. In some degree they approach plastics.

There is evidence that in the turbulent flow range N_r—2100, the friction of paper stock is nearly the same as water.

James Cooper, Jr. (*Tech. Assoc. Papers, XXV, 407–411*) made an interesting analysis of the problem and reached the conclusion that the principle of dynamic similarity can be applied so that working back from Reynolds numbers for a given stock, an apparent viscosity can be obtained. This he expressed as

$$\log \frac{0.095DC^3}{M} = 0.05U$$

for sulphite stock. Using the apparent viscosity obtained from this relation, the Reynolds number can be obtained and the friction calculated in the normal manner. The accuracy of this method falls within the generally accepted limits, with some modification of the formula indicated for very low velocities and other types of stock.

The above procedure requires considerable calculation in determining the pressure drop value. However, since its application is necessary only for the viscous flow range, it becomes feasible to simplify it. The following steps show how this can be done:

(*continued on page 74 A*)

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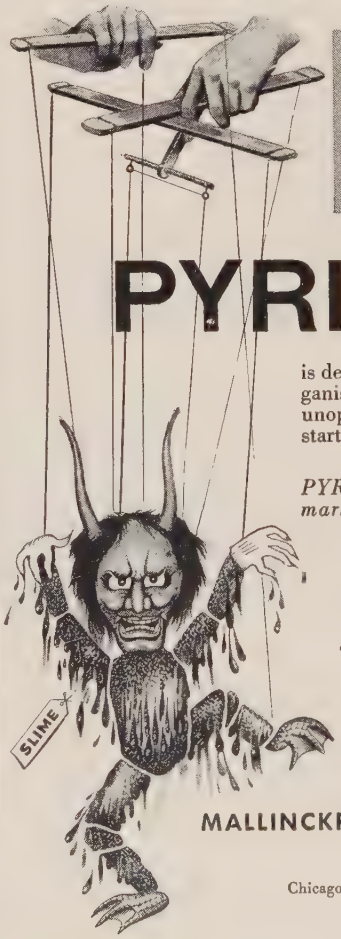

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(*continued from page 72 A*)

$$f = \frac{M}{L}\,\frac{Dg}{2U^2}$$

In the viscous flow range

$$K = fN_r \text{ and } f = \frac{K}{N_r}$$

where K is a constant

$$N_r = \frac{DUe}{M}$$

Substituting we have

$$\frac{KM}{DUe} = \frac{H}{L}\,\frac{Dg}{2U^2}$$

and

$$\frac{H}{L} = \frac{2UKM}{D^2ge}$$

from

$$\log \frac{0.095DC^3}{M} = 0.05U$$

we determine that

$$M = \frac{0.095DC^3}{10^{0.05U}}$$

and substituting

$$\frac{H}{L} = \frac{2UK\,\dfrac{0.095DC^3}{10^{0.05U}}}{D^2ge}$$

Since stock density is practically constant at 62.3 pounds per cubic foot regardless of consistency, we can combine all the constants into one

$$A = \frac{2K0.095}{ge}$$

and

$$\frac{H}{L} = \frac{AUDC^3}{D^2 10^{0.05U}}$$

$$= \frac{AUC^3}{D10^{0.05U}}$$

From the N_r vs. F relation $K = 15.9$

$$A = \frac{2 \times 15.9 \times 0.095}{32.2 \times 62.3} = 0.00151$$

if AH is feet head loss per 100 feet of pipe then

$$AH = \frac{0.151UC^3}{D10^{0.05U}}$$

While this involves a burdensome calculation, to solve, it plots very readily. This plot can be readily checked against available test data. Lacking such test data points, the available TAPPI and Cameron friction charts have been spotted against the per cent consistency curves (CP-563A).

The form of chart lends itself to compilation of pressure drop curves based only on accurate tests as such data become available; i.e., even if the relations from which the chart was prepared were in error, a back plotting of test data would indicate the proper location of the per cent consistency lines, and new charts could be prepared based solely on test results. It may well be that several charts will be needed, each for a different type of stock (groundwood, sulphite, etc.).

It is suspected that paper stocks and similar suspensions may move into the turbulent flow range at lower N_r than 2100 when consistency is high.

The steps that must be taken to prepare charts of known accuracy therefore are:

1. Develop a uniform and consistent test method to obtain accurate readings.
2. Arrange for tests to be run and for test data to be submitted to a central analyzing committee.

In further consideration of the variables, it is important to classify all tests as to: source of stock, freeness of stock, degree of working applied to stock prior to test.

In connection with the third item, degree of working, it is known that a paper stock continuously circulated seems to acquire a lower apparent viscosity with the length of time circulated.

This report is made to suggest a method of obtaining pipe-friction curves for paper stocks based on test data. The furnishing of this data promptly and completely must be left to TAPPI members who manufacture paper stocks.

Mr. Goldsmith: Thank you, Mr. Gerbereux. That ends the data which is being presented. The presentation of the data was for the purpose of outlining the type of most important information that is available today. At this point the meeting is thrown open to discussion.

Question: I would like to bring up the factor of the roughness of the walls, woodlined, cast iron, etc. Has data been published in that regard?

Mr. Gerbereux: I think that the difference in roughness can be brought into the problem because for viscous flow reading, you can get a direct multiplier factor which will tell you that for one roughness you get such and such a friction, multiplied by that factor, you get the friction for another roughness.

It is possible on paper stock that the roughness factor may also have to take into consideration another item—velocity? I think that is quite possible. In other words, while on water or a petroleum fluid you can use a direct multiplier, I expect that on paper stock it will be a direct multiplier times some other thing.

Question: I note in the discussion that we have gone over about ten different variables that affect the flow of stock in pipe. I wonder what we know about instrumentation for measuring all of these variables accurately.

Answer: I would suggest a basis of approach as followed by the metallurgists and physicists in approaching a similar problem. It may be helpful here. This is also in support of Dr. Galley's theory inserting the ratio of greater to least diameter or, in other words, length to diameter of fiber in question. In past years, work has been done on the study of plastic flow of metals. Now metals are a heterogeneous mass similar to paper stock consisting of all shapes and forms, especially alloys, so that to hit a ground, they developed the simplest forms, the core metals first. It was found that if the slip planes occur where the atoms are of the body centered type, that is the atoms are spherical, the slip is least. Where they are the face-centered type, there they are elliptical, the greater dimension to the least dimension that the friction increases as direct function of that relationship between the two dimensions. Of course, they are going to progress on and take the next complex step by adding a known shape to it and later add a third and so forth. It may be possible in the approach to this problem to segregate the factors one at a time to see what their performance is and then see what happens when you put them all together.

Question: May I ask whether in your opinion that could be done in the field, or would that have to be done in a research center?

Answer: I am afraid that it would have to be done in a research center because in the field you do not have any simple arrangement anywhere.

Mr. Agronin: This question of instrumentation is some-

(*continued on page 76 A*)

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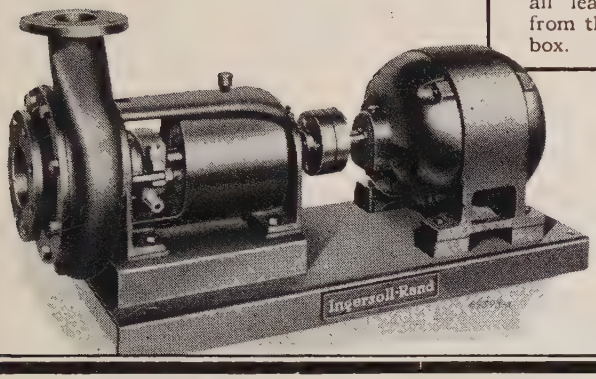

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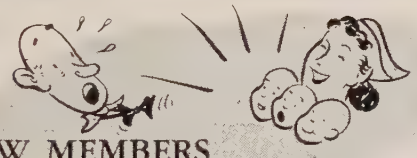

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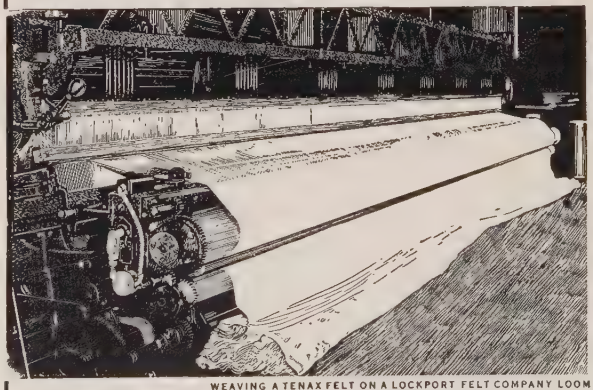

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(*continued from page 74 A*)

thing that bothers everybody who works with paper stock. I hate to say this to a group of TAPPI members, some of whom are chemists, but there are no instruments of any value on a correlated basis in this game. Instruments have been developed such as the freeness tester which works very well in one specific mill on one specific type of stock. In other words, the papermaker has been able to use that instrument to gage his own production to gage his own test. Those of us who attempt to correlate mill A against mill X finds that the test is no good at all. Now, one of the basic things to take into consideration in testing will have to be better instruments. We, in our Dilts Laboratory, are doing a tremendous amount of work, directly and indirectly on determining and correlating various instruments. One of the factors which is used in testing stock is freeness, which is more or less a universal term. The fact is it is an accepted form. Now, as far as trying to correlate any results in terms of Canadian freeness mill A just does not do it. So we are looking for other factors. So the next person comes along and says freeness is indicative of fiber length and drainage capacity, or friction value, so we have been working on that basis. Another individual comes along and says that your fiber length factor is a good indication of what is happening, so Martini in Canada developed that grid and we have been working on that. Now, I just heard from McGill that they did a lot of work in their laboratory on the Clark fiber-length tester. Those are all factors. Before any definite work is done you had better get back to the basic factors.

To be honest with you, so far we are just at a loss. Now this question of friction drop is very important. This rifling of pipe may be the answer. We have no trouble in stock around 3 to 4%, but when you get up in 8 and 9% we have been very lucky, all of us who have gone into that particular field, in that we have had relatively little trouble in furnishing equipment for this. But one of the basic differences is trying to maintain a uniform consistency in 10 feet of pipe. You cannot maintain some of it in 10 feet of open chest. When you add a frictional loss, you can appreciate some of the factors. Now, as I say, too many viscosities and fiber lengths are one of the factors.

Perhaps some bright young fellow will come out with an entirely new factor which will include something that we have missed so far which will give us an answer to this problem. I will be honest with you that up to now we have looked at this for a long time in our organization and we have not yet found any factor that we can start with to correlate from. Mr. Gerbereux has developed it in terms of viscosity but, of course, he will tell you that viscosity is something that you cannot seem to pin down. You cannot measure it. You have no way we know of measuring it.

Now one of the basic considerations in developing better curves is entirely based on this instrumentation factor. We published a set of curves based entirely on instrumentation factors and we get very good results when we apply them. The greatest trouble is when a mill man tries to apply them, he just does not know what constants to use. They will come to us and say, "Look we figured 140 feet and you figured 120 feet." Well, inherently we apply the factors in terms that we know that the stock came from there, and we know the pipe is in such a condition, and we know this and we know that, true, as an experience factor, we have it, but try to pin it down and tell the other guy.

Dr. Galley: To the best of my knowledge, no one has ever used a more precise research instrument for measuring viscosity. I am thinking of an instrument like the Cuette viscosimeter which is the torsional type and in which end corrections have been taken care of and other such troublesome factors. Does anyone know whether a really precise instrument of that kind has been used for pulp?

Answer: In the Institute, Gray's tester has been found to be the best for this purpose.

Dr. Galley: I would suggest that that would be the best place to start in a program for the measurement of viscosity.

Mr. Goldsmith: Does the question boil down to this? Until you can define a special stock, you cannot say what your data represents. In other words, in any major project in any attempt to establish good friction curves for general use in the industry that could be standards, you would have to define the particular stock in some terms. You can say where it came from, you can say what treatment it has had, you can give its freeness on some scale, but can you by some such designation as a viscosity description specify that stock in a manner that 10 years hence another investigator will get substantially similar results that he could re-establish those conditions?

Dr. Galley: Well, I think that the viscosity measurements can be looked upon as an integration of a number of these factors. In addition there will still have to be corrections for roughness of the wall, possibly wall material, but insofar as friction within the stock is concerned, I think that should be worked up as a standard part of integration to which we would go back years later and get an over-all figure. Now if one made a number of measurements of viscosity and different types of stock and different types of treatment, etc., I think in addition to getting this over-all integrated figure of viscosity, a general picture would arise as to the effect of all these other factors, what effect they would have, fiber length, amount of fibrillation, different types of stock, etc. That would have to appear as the result of a large mass of data. Meantime, it still seems to me we need these viscosity figures, dropping in as standard a manner as we can make them, taking into account criticisms we have to make of them.

Mr. Goldsmith: Do you believe, Dr. Galley, for purposes of these tests, viscosity description in terms of a test or a curve of a given stock would cover the characteristics of that stock as far as it applied to the friction of that stock?

Dr. Galley: Yes.

Mr. Goldsmith: Is there an instrument or a method for establishing this viscosity?

Dr. Galley: I believe, offhand, that there are types of instruments which have been used for similar suspensions in other fields which have been of real value there like the one I mentioned, the Cuette type, would serve a really useful purpose in this field.

Mr. Goldsmith: We have here what sounds like a cornerstone to any project undertaken. The question of returning each specific stock on which tests might be made to an attempt to express it in terms of viscosity. What is the thought of the meeting? Does the meeting agree with Dr. Galley that some type of viscosity test is likely to give a basis for differentiating different stocks and for the purpose of defining different stocks so that in practical use people can take the one closest to their own conditions? Could we have some expressions?

Question: How much weight can we put on Mr. Mackenzie's figures on flow in pipe? We have practically the same stock tested in the same manner, yet minor differences make a major difference in velocity.

Answer: We do not know what his viscosity was and also we may find that the minor differences noted might turn out to be major ones.

Dr. Galley: I rather suspect that we are trying to measure something that is a little bit more than viscosity. I would not attempt, however, to give it a name until such a time as we have determined that there may be another factor in it. The gathering of statistical data, until such time as we can discover a meaning to it, is the only way we

(*continued on page 78 A*)

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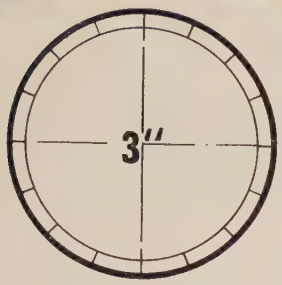

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(*continued from page 76 A*)

will ever get a true verification of the picture. We should not be discouraged by the fact that some of these results seem to be so far apart. After all there are probably less than a few hundred gathered so far. You need a few thousand items put together to get reliable statistical data on something as complex as this. I think it would be best to continue to gather data, get it and put it together and narrow the range down as time goes on to see what the pattern actually is.

Mr. Forrest: I have some viscosity curves which were run by a paper mill and I will have to get their permission before I can turn them over. If I can get their permission, I will be very glad to do so. I believe they were taken on the Storemermeter or something like that, I believe that is what they were run on.

Mr. Goldsmith: May I ask a question before the group? We have had outlined here the present knowledge of a subject which is extremely important to all engineers in our industry. Is it desirable, is it timely that a project be undertaken by TAPPI to verify and consolidate the various sets of curves which today exist, and to establish a set of standard curves incorporating the information existing after it has been verified and checked, and the new information it might be desirable to obtain. Is it the opinion of this group that we should undertake a project of this scope? Would anybody care to comment?

We have had from Mr. Shaw the expression of interest on the part of his company and I think we could probably count on a great deal of assistance from the other leading hydraulic firms who are represented here on the panel.

Col. Johnston: I think we should have a subcommittee to carry this subject further.

Mr. Goldsmith: I think that was a very fine suggestion, Col. Johnston suggested a subcommittee of this committee to study this subject in view of the material available today to set up a plan of approach and set up a tentative procedure for mill testing in the light of the instrumentation available today. If that is the consensus of the group, we will appoint such a subcommittee. Do we have other comments? What is the general feeling?

Comment: I would like to point out that I think the feeling at the Institute that Dr. Van den Akker has is that he feels you cannot go too far with small equipment in measuring these effects. The equipment that Gray used was the Stormer type viscosimeter of at least a foot in diameter, but in the problem they were working on, they felt they had to get sufficiently large equipment so that the equipment is much larger than the diameter and length of fiber. I think there should be some limitation on the work very definitely.

Mr. Goldsmith: You mean as far as the laboratory work?

Response: Yes, they feel that they cannot go very far in using laboratory data because with small scale equipment, you are not able to correlate.

Mr. Goldsmith: Aren't we coming to the point where we need both, to a realization that to advance a project of this scope we would have to get specific stock. We would have to find a way of setting up a test run in a mill defining the stock in that mill, possibly out of the beater chest and back into the beater chest so that the operation is not interfered with in any sense, and correlate that with whatever factors can be more easily established in the lab. Is that what our thinking is coming to?

Mr. Gerbereux: No matter where it comes from, the mill or the laboratory, it should be obtained in a uniform manner, otherwise you are just fooling yourself to try to compare it.

Mr. Goldsmith: Gentlemen: In order to test the sense of this group in undertaking a project we want to feel certain there is the interest behind it, will somebody make such a motion, or just a show of hands of those who think such a project undertaken could be productive. It would be a long one. Could we have a show of hands to show the amount of interest existing? Thank you very much.

Your Chairman would then like to designate Mr. Mackenzie of Eastman Kodak as the Chairman of this subcommittee and in due course I know you will all hear from him.

Mr. Goldsmith: Suppose we leave it to the subcommittee to seek its own members. We know it will need to represent the pump manufacturing concerns, we know it will have to represent the leading research institutions and leading researchers in the field, we know it will have to include the practical mill engineers in whose terms it will have to finally add up, and who have to use it. So in behalf of this committee, I want to thank you gentlemen for offering to serve on this subcommittee and I know Mr. Mackenzie will be glad to coordinate it.

Mr. Hall: I was in hopes that we would have a review of B & H by Dr. Naedelman, but since he did not present his report, you might be interested in a few figures which I have taken down from those of the Brecht & Heller reports. If you folks think you are mixed up in the friction loss data which is available in this country, you should get this B & H stuff. Taking 5% consistency through an 8-inch pipe at 1200 r.p.m., the Hydraulic Institute shows a friction loss of about 70 ft. per 100. B & H shows it as only 30. If you come back to $3^1/_2$%, the Hydraulic Institute for the same capacity gives a friction loss of 23 and Heller & Brecht (?) show 11. (8-inch pipe, sulphite 1200 gal.)

When I first got this information I wrote to the Swedish DeLaval Company and asked them what information they had available and they said to be perfectly frank, they did not have anything available which they would consider accurate. They found, on the continent, a variation between different manufacturers of about 300%. I wrote to Mather & Platt and asked them what information they had and after you read their long letter, it comes down to about, take your own value because as I said, it will probably be as accurate as anything we have. I think we certainly need this information. Heller & Brecht reports are all written in German and I had difficulty translating them, but I have here two sets of curves which I took, which while not 100% accurate, they do show the fairly close translation of what he has worked out. In general, I would say that the H & B reports show that the friction loss according to their method of testing, is about half of what we are now using. It might be interesting to mention that taking 1200 gal. H & B say 30, and I think on that slide rule of yours, Tany, it gets up to over 100, that is 5% through an 8-inch pipe at 1200 gal.

Mr. Agronin: We would figure about 75.

Mr. Hall: There is 75, 70, and 30 and I think if you took the Gould data you would get another value. So I really think there should be something done. It is really confusing.

Comment: I believe there is another way to approach this problem. I believe if we could encourage some bright young student to become interested and encourage him to get a theoretical solution, we might be able to uncover information which would be of vital importance and would certainly solve our wondering in regard to the variables.

Mr. Goldsmith: May I say that the subcommittee will attempt to make such a plan and make any recommendations which they feel will be justified toward work of the kind you suggest on the part of students, which may have to wait until we have something to show before we can go to Mr. Hemphill and Mr. Macdonald and ask for funds. But give them a project under way and then I know we could count on a very favorable consideration.

May I say this, the subcommittee which has just been formed, will need interested engineers, mill engineers. Any

of you who are not associated with the TAPPI committee and who are interested in this project, please get in touch with us because I believe this will be a very interesting and long way project. It is in my mind, something like the dry work which the drying committee has been doing. It is going to require doing in it sections year by year. A specific stock this year, another specific the next year, and over a period of time it should result in standard curves where we will all be speaking the same language.

Are there any other comments to be made at this time. The subject is too great for us to attempt to cover it in any greater detail and I believe we have roughed it out quite well.

If there is no further discussion and it is your desire to adjourn, at this point, I think it would be in order.

Preliminary Report of Hydraulic Subcommittee

At the November Engineering Conference in Buffalo, N. Y., a subcommittee of the Fundamental Engineering and Research Committee was established to study the problem of friction loss from stock flow in pipes. This committee was named "Hydraulic Subcommittee."

At the Buffalo meeting a number of speakers took part in a symposium on this subject and the conclusions that were drawn from this symposium were that there was considerable confusion in the industry as a whole on this subject and that there was considerable conflict in the data that had been published on this subject to date.

In order to get a statistical picture of how bad this confusion was a questionnaire was sent out to the eleven leading pump manufacturers in the eastern part of the United States supplying the paper industry with centrifugal pumps. This questionnaire covered the basic curves they use for calculating stock friction, the correction factors they use for various types of pulp, and the correction factors they use for various different pipe materials. The following is a summary of their replies:

Five pump manufacturers use the Allis-Chalmers Curves exclusively.
One pump manufacturer uses both Allis-Chalmers and Cameron.
One pump manufacturer uses Allis-Chalmers Curves for small volumes and Shartle Curves for large volumes.
One pump manufacturer uses the Allis-Chalmers Groundwood Curve.
One pump manufacturer uses the Cameron Curve exclusively.
One pump manufacturer uses the Shartle Curves exclusively.

A casual study of these curves will show quite a difference for any particular point between the readings on the three different curves. To show how these vary, the variances for sulphite pulp were calculated for a 6- and a 12-inch pipe. These were averaged over the full range of the curve in question and the following relationship was obtained. Allis-Chalmers Sulphite Curve was taken as 100% simply to establish a base. There is nothing to indicate that it is any more reliable than the other curves, as they were all presumably obtained under similar conditions of accuracy. If we assume the Allis-Chalmers Sulphite Curve as 100% in a 6-inch pipe, the Shartle Curve will give us an average reading of 250%, while the Cameron Curve will give an average reading of 150%. In a 12-inch pipe we assume the Allis-Chalmers Curve at 100%, the average deviation of the Shartle Curve will be 112%, and the Cameron Curve 93%. Individual point variations from the Allis-Chalmers Curve vary anywhere from 67 to 285%. This information alone indicates the need for an establishment of this Hydraulic Subcommittee and the necessity for some fundamental studies in the head loss resulting from the flow of paper stock in pipes.

Correction Factors for Various Pulps

In reply to the questionnaire with respect to the correction factors used for various pulps, one pulp manufacturer stated that they accepted the purchaser's head specifications and did not make any corrections themselves. A second pump manufacturer stated that their district engineers used their own judgment and there were no established correction factors maintained at the home office. A third pump manufacturer stated that they made no corrections for different types of stock, except in the case of groundwood where they used the Allis-Chalmers Groundwood Curve. The remaining seven pump manufacturers that replied gave correction factors for some or all of the following pulps. The following tabulation gives the high, low, and average for each pulp, using raw sulphite as 100%. The following tabulation is for pump manufacturers using the Allis-Chalmers Curves:

Pulp	*High, %*	*Average, %*	*Low, %*
Raw sulphate	125	106	100
Bleached sulphite	110	98	80
Bleached sulphate	110	100	90
Soda	100	94	85
Straw	100	92	85
Rag	100	98	85
Refined stock	100	96	80
Mixed papers	100	90	70
Loaded stock	110	94	65

The corrections for the Cameron Curves in general are higher than those used for the Allis-Chalmers Curves, while the corrections for the Shartle Curves are in general much lower than those used for the Allis-Chalmers Curves.

Corrections for Different Types of Pipe

Eight pump manufacturers submitted correction factors for some or all of the following different types of pipe. These factors have been averaged using old cast iron pipe as equivalent to 100%.

Type Material	High, %	*Average, %*	*Low, %*
Spiral riveted	110	101	100
Wood stave	100	84	80
Copper	140	93	62
Cement lined	4 at 100% and 1 at 54%		
Rubber lined	100	80	50
New pipe	115	105	100
Transite	1 manufacturer only—75%		

It can be seen from the above that two pump manufacturers using the Allis-Chalmers Curves for Bleached Sulphite through copper lines could vary 300% in their pipe friction loss calculation, while two manufacturers using different curves for Raw Sulphate through cast-iron pipe could vary as much as 350% in their calculations of friction loss.

K. J. Mackenzie, *Chairman*

Fourth Engineering Conference

Statler Hotel, Boston, Mass.

PROGRAM

Sunday, October 30

3:00 p.m. REGISTRATION (*Mezzanine*)

Monday, October 31

8:30 a.m. REGISTRATION (*Mezzanine*)

9:15 a.m. GENERAL SESSION (*Georgian Room*)
George H. Pringle, *General Chairman*
Opening Remarks, by A. E. Bachmann, Missisquoi Corp., *President,* TAPPI

9:30 a.m.
MILL DESIGN AND ECONOMIC ASPECTS SESSION (*Georgian Room*)
A. H. Johnson, Consulting Engr., *Chairman*
"Pulp and Paper Mill Building Design," by M. C. Celli, Rust Engineering Co.
"Paper Machine Drives," by Roland A. Packard, Holyoke Machine Co.

11:15 a.m. ENGINEERING DATA SHEETS SESSION (*Georgian Room*)
Henry J. Perry, Consultant, *Chairman*
Discussion of Plans for Supplementing the TAPPI Engineering Data Sheet Service

12:30 p.m. LUNCHEON (WHERE YOU WILL)
Note: Committee luncheons as arranged by chairmen.

2:00 p.m. ENGINEERING RESEARCH AND MACHINE DESIGN SESSION (*Georgian Room*)
P. H. Goldsmith, Pusey & Jones Corp., *Chairman*
"Suggested Standardization of Spherical Bearings on the Wet End and Drier Sections of Paper Machines," by G. H. Spencer, The Torrington Co.
"Beta-Ray Basis Weight Gauge," by E. A. Crawford and M. Strain, Continental Paper Co.

3:30 p.m. MATERIALS HANDLING SESSION (*Georgian Room*)
G. H. Wadleigh, Consulting Engineer, *Chairman*
"Conveyors in Pulp and Paper Mills," by S. L. Foster, Kalamazoo Vegetable Parchment Co.

Tuesday, November 1

9:00 a.m. STEAM AND POWER SESSION (*Georgian Room*)
Charles J. Sibler, West Virginia Pulp & Paper Co., *Chairman*
"Recovery of Waste Heat in Paper Mills," by D. K. Dean, Foster-Wheeler Corp.
"Selection of Steam Pressures and Temperatures for Paper Mill Power Plants," by M. H. Dixon, St. Regis Paper Co. and W. C. Bloomquist and W. B. Wilson, General Electric Co.

10:45 a.m. MILL MAINTENANCE AND MATERIALS SESSION (*Georgian Room*)
William McIntosh, Jr., Southern Corp., *Chairman*
"Maintenance Costs in a Fine Paper Mill," by D. Ross-Ross, Howard Smith Paper Mills.
"Process Piping Other than Black Pipe," by Fred V. Doutt, Champion Paper & Fiber Co.
"Use of Transite Pipe in the Pulp and Paper Industry," by C. W. Ziegenbusch, Mead Corp.

12:30 p.m. LUNCHEON (WHERE YOU WILL)

2:00 p.m. ROUND TABLE SESSIONS:

A. STEAM AND POWER (*Georgian Room*)
"Standardization of Steam Turbines for Paper Mills," by J. C. Spahr, Westinghouse Electric Corp. and J. L. Kerr, General Electric Co.
Discussion led by H. R. Arnold. Union Bag & Paper Corp.
"Acid or Solvent Cleaning of Boilers," by C. H. Groom, Dowell, Inc.
Discussion led by M. F. Schnaufer, Detroit Sulphite Pulp & Paper Co.
"Instrumentation of Steam and Power Plants"
Discussion led by F. E. Hutton, Babcock & Wilcox Co.

B. MILL DESIGN AND ENGINEERING ASPECTS (*Parlor C*)
"Paper Machine Drives"
Discussion led by R. A. Packard

C. ENGINEERING RESEARCH AND MACHINE DESIGN (*Parlor A*)
"Stock Flow and Pipe Friction Drop"
Discussion of Project of the Hydraulics Subcommittee led by K. J. Mackenzie, Eastman Kodak Co., *Chairman*

D. MATERIALS HANDLING (*Parlors D and E*)
Discussion of S. L. Foster's paper and Miscellaneous Inquiries, led by George R. Wadleigh, *Chairman*

E. PAPER MANUFACTURE (FOURDRINIER) (*Parlor B*)
"Paper Machine Stock Inlets."
Discussion led by Noel Phillips, Champion Paper & Fibre Co., *Chairman.*

6:00 p.m. GET-TOGETHER PARTY (*Ballroom Foyer*)

7:00 p.m. SPONSOR'S DINNER (*Ballroom*)

Wednesday, November 2

9:00 a.m. DRYING AND VENTILATING SESSION (*Georgian Room*)
A. E. Montgomery, J. O. Ross Engineering Co., *Chairman*
"Water Heating System and Briner Economizer," by A. C. Smith, Newton Falls Paper Co.
"Heating and Ventilating the M. & O. Paper Co. Bleachery," by J. H. Davidson, Minnesota & Ontario Paper Co.

10:45 a.m. ELECTRICAL ENGINEERING SESSION
A. S. Goodrich, Hammermill Paper Co., *Chairman*
"Power Requirements for Paper Machines" First Report on Committee Project, by A. S. Goodrich, *Chairman*
"Electrification of a Pulp and Paper Mill," by J. C. Lynch, Hammermill Paper Co.

12:30 p.m. TAPPI ENGINEERING DIVISION LUNCHEON
A. E. Bachmann, *Chairman*
Speaker: Dr. George R. Harrison, Dean of Science, Massachusetts Institute of Technology

2:00 p.m. ROUND-TABLE SESSIONS:

F. MILL MAINTENANCE AND MATERIALS (*Parlor A*)
"Effect of Carbon Powder Preparation on Plain Carbon Steels," by Milton Stoll, formerly Professor of Metallurgy, Polytechnic Institute of Brooklyn

Question Box on Maintenance led by Wm. McIntosh, Jr., *Chairman*

G. Electrical Engineering (*Parlor C*)
Discussion of Power Requirements Report led by A. S. Goodrich, *Chairman*

H. Drying and Ventilating (*Georgian Room*)
Discussion of Air Filtration, led by A. E. Montgomery, *Chairman*

I. Paper Manufacture (Cylinder) (*Parlor B*)
Discussion of Cylinder Machine Operation, led by A. E. Bachmann

J. Data Sheet (*Parlors D and E*)
Organization of Data Sheets Committee and Outline of Program of Work, led by Henry J. Perry, *Chairman*

Thursday, November 3

9:30 a.m. Plant Visits Leave from Hotel Statler

1. Walpole Trip: To Bird & Son, Inc. Bird Machine Co., The Foxboro Co., and Draper Bros. Co. plants.
2. Worcester Trip: To Rice Barton Corp., Norton Co., Riley Stoker Corp., and Lodding Engineering Co., plants.
3. Lynn Trip: To General Electric Co., River Works.
4. Hyde Park Trip: To Sturtevant Div., Westinghouse Electric Corp. plant

Note: Transportation to the plants mentioned in these trips will be furnished and luncheon served through the courtesy of the host companies.

Room Reservations: Adequate housing facilities have been arranged at the Statler Hotel. In making reservations be sure to mention the TAPPI Engineering Conference. In past conferences a very large number arrived on Sunday. Registration facilities will be available at 3 p.m.

Fibrous Agricultural Residues Meeting

S. I. Aronovsky, Chairman, TAPPI Fibrous Agricultural Residues Committee, announces that the fall conference sponsored by this Committee will be held at the Terre Haute House, Terre Haute, Ind., on November 7–8, 1949.

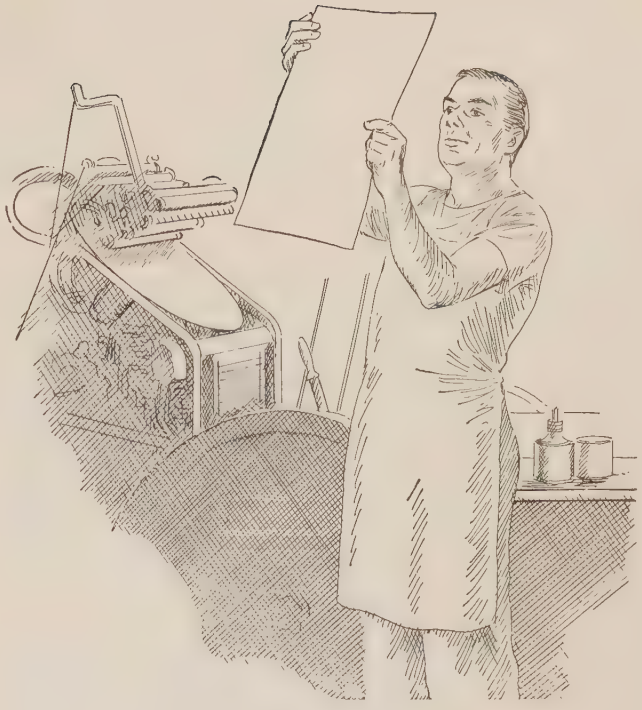
The tentative plans for the meeting cover two sessions on straw pulping, processing, and refining on November 7. The meeting of the whole Committee, with reports of the activities of the various subcommittees, will be held on Tuesday morning, November 8. This meeting will be open to all who may be interested. The afternoon of November 8 will be devoted to visits to the mill of The Terre Haute Paper Co., and to other industrial plants in Terre Haute and vicinity.

R. F. Burns, Vice-President of The Terre Haute Paper Co., host company of the meeting, will be Chairman of the Arrangements Committee.

1950 Nominating Committee Report

The Report of the 1950 Nominating Committee was published on page 54A of July *Tappi*. Since it was published, W. B. Lincoln of the Inland Container Co. has found it necessary to retire as a member of the Executive Committee.

Henry J. Perry, Chairman of the Nominating Committee, reports that the Committee has approved the nomination of Richard P. Price, Vice-President and General Superintendent of the Hammermill Paper Co., Erie, Pa. to serve the one year remaining in Mr. Lincoln's term as member of the Executive Committee. Mr. Price's name will be included in the letter ballot to be sent later in the year to all members for vote.



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LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Pacific

The Executive Committee of the Pacific Section met on July 22 and was attended by W. F. Holzer, *Chairman,* R. I. Thieme, H. C. Wall, H. W. Bialkowsky, Otto H. Sangder, Ben Natwick, R. M. True, O. K. Chapman, F. J. Weleber, John E. Robison, Max R. Oberdorfer, and J. L. McCarthy.

It was again decided to hold four meetings in addition to the annual meeting which will be held in May or June, 1950. These will be held on October 25, 1949; December 6, 1949; February 7, 1950; and April 7, 1950. They will be devoted to Engineering, Instrumentation, Paper Making and Converting, and to the Shibley Award Committee. The December meeting will be held jointly with the Superintendents Pacific Division.

The following resolution was adopted:

"The Pacific Section of TAPPI recognizes the outstanding job which has been done in the publication of the new Technical Association Journal *Tappi.* This Section commends the National Officers, the Executive Committee, the Editor, and Editorial Board for their excellent work and expresses appreciation for their accomplishments."

Ohio

The first meeting of the Ohio Section will be held at the Hotel Manchester, Middletown, Ohio, on October 13. The speaker will be Allen Abrams, *Vice President,* The Marathon Corp., Rothschild, Wis.

Chairman Art Thurn has appointed the following to membership of the Section Publicity Committee: *Chairman* —Earl Knapp, Auglaize Box Board Co., St. Marys; Herb. Smith, Mead Corp., Chillicothe; Don Goodman, Sorg Paper Co., Middletown; Harold Koch, Aetna Paper Co., Dayton; and Harold Joiner, Champion Paper & Fibre Co., Hamilton.

Lake Erie

A new prospective local section is in process of being formed to serve the area from Erie, Pa., to Monroe, Mich., and for about 100 miles south of Lake Erie. A preliminary organization committee meeting was held on July 22 at Cleveland, Ohio, and was attended by Lewis Burnett, Ohio Boxboard Co., Rittman, Ohio; W. D. Manor Consolidated Paper Co., Monroe, Mich.; C. P. Springer, Chase Bag Co., Chagrin Falls, Ohio; and Wm. Schoenberg, Lord & Schoenberg, Cleveland, Ohio.

At that time a temporary name was selected—The Lake Erie Papermills and Converters Technical Association. Meetings will be held on the first Friday of each month, starting on October 7 at Cleveland. The October 7th meeting will be held at the Hickory Grill, 929 Chester Ave., Cleveland, at 6:30 p.m. The subject of the meeting discussion will be "Paper and Paperboard Finishes."

Although notices of this meeting have been sent to all TAPPI members in the region, details concerning the Group may be obtained from William Schoenberg, Lord & Schoenberg, 1200 West 9th Street, Cleveland 13, Ohio (Telephone: Tower 1-8147).

Ed. Note: It is the practice of the national association not to organize any of its local sections. Members interested in forming prospective sections are encouraged to do so and may receive such help as may be necessary from the National Association. The first step is to form an independent body which is generally called a Group, although this designation is not necessary. When it is evident that the Group has the qualities that will enable it to survive it may apply for a charter from TAPPI. Since the success of a local body depends on good leadership that must function without much outside help this practice has been found to be quite sound. Each section has had to depend upon itself and consequently has maintained a very high quality of executive leadership from the start.

Delaware Valley

The first meeting of the Delaware Valley Section will be held at Spring Brove, Pa., on Friday, September 30. A feature of this meeting will be a visit to the H. P. Glatfelter Company's mill in the afternoon. The dinner meeting will start at 5:30 p.m. E. W. Clem, Chief Engineer of Rice Barton Corp., Worcester, Mass., will discuss some of the newer developments on paper machines.

The programs for the remaining meetings of the year will include printing, quality control, pulp testing and drying, as well as panels on sizing and mill maintenance.

Maine-New Hampshire

The Maine-New Hampshire Section will meet on October 21–22, 1949 at the Lafayette Hotel, Portland, Me. The technical sessions will be held at 2:00 p.m. on the 21st and at 9:00 a.m. on the 22nd. The general theme will be "Chemical Reinforcers." At a panel discussion, on Saturday the 22nd, emphasis will be given to the use of starch in paper.

The meeting will be terminated in time to permit attendance at either the Colby-Bowdoin football game at Brunswick or the Maine-Bates game at Lewiston.

The Program Committee consists of G. A. Day, Brown Co., R. S. French, Keyes Fibre Co., and J. B. Calkin, University of Maine. The Arrangements Committee is composed of J. J. Thomas, S. D. Warren Co.; F. H. Frost, S. D. Warren Co.; and H. E. Pratt, Pejepscot Paper Co. John L. Parsons, Hollingsworth & Whitney Co. is *Chairman* of the Section.

RECENT BOOKS

Industrial Rheology and Rheological Structures. By Henry Green. John Wiley & Sons, Inc., New York. 1949. Cloth 5½ × 8½, 311 pages. Illustrated. $5.50.

The purpose of this book is to give the laboratory man a workable rheological system which can be used for research or plant control purposes in the field of coatings, printing inks, resins, plastics, asphalt, etc.

It is an advanced work and does much to correlate the work of the microscopist and the rheologist. It deals with such subjects as microscopical examination of flow, viscosity, thixotropy, plastic flow, laboratory measurements, particle size, etc.

Mr. Green (now deceased), formerly of the Interchemical Corp. has participated in TAPPI coating meetings.

Copies may be obtained from TAPPI, 122 East 42nd Street, New York 17, N. Y.

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Derry Akeroyd, Engineer, Paper Div., Personal Products Corp., Milltown, N. J., a 1943 graduate of Newark College of Engineering.

Maurice S. Anderson, Chemical Engineer, Oxford Paper Co., Rumford, Me., a 1937 graduate of Northeastern University.

Sydney R. Annett, Chemical Sales Development, Monsanto Canada Ltd., LaSalle, P. Q., Canada, a 1938 graduate of McGill University.

LeRoy J. Bauer, Sales Engineer, Shartle Brothers Machine Co., Middletown, Ohio. Attended University of Cincinnati.

Geoffrey Broughton, Head, Dept. of Pulp and Paper Chemistry, Lowell Textile Institute, Lowell, Mass., a 1938 graduate of Massachusetts Institute of Technology.

Emery Brugh, Paper Testing, Time, Inc., New York, N. Y.

Leopold A. Demolder, Chemical Engineer, Papeteries de Genval, Genval, Belgium, a 1924 graduate of the University of Strasbourg.

Milton W. Dippold, Industrial Chemist, Spencer Kellogg & Sons, Inc., Decatur, Ill., a 1943 graduate of James Millikin University.

John W. Donohue, Superintendent, Blackstone Glazed Paper Co., Pawtucket, R. I.

Allen W. Evans, Chief Chemist, Southalls (Birmingham) Ltd., Saltley, Birmingham, England, a 1923 graduate of Birmingham College.

Lawrence Gussman, Vice-President in charge of Technical and Manufacturing Div., Stein, Hall & Co., Inc., New York, N. Y., a 1937 graduate of Columbia University.

Frederic D. Helversen, Chief Industrial Engineer, Crown Zellerbach Corp., Portland, Ore., a 1939 graduate of Massachusetts Institute of Technology with an M.S. degree.

Jean E. G. Hery, Engineer, Edouard Hery Consultants, Paris, France, a 1935 graduate of Ecole Nationale des Pouts et Chaunees de France.

E. Langford Jones, Chief Chemist, Hercules Powder Co., Hopewell, Va., a 1939 graduate of William and Mary College.

Theodor N. Kleinert, Head, Cellulose Research Div., Lenzinger Zellwolle- und Papierfabrik A/G, Lenzing, Oberosterreich, Austria, a 1924 graduate of Technical University, Vienna, with a Ph.D. degree.

Jacob Lichman, Vice-President in charge of Sales, American Resinous Chemicals Corp., Peabody, Mass., a 1934 graduate of Boston University.

Nils B. Lundgren, Chief Chemist, Holmens Bruks och Fabriks (A/B, Norrkoping, Sweden, a 1939 graduate of The Royal Swedish Technical University.

George R. Marsh, Engineer, C. J. Merrill, Inc., Portland, Me., a 1931 graduate of Tufts College.

Oscar L. Miller, Assistant to President, Balsthal Paper Mill, Balsthal, Switzerland, a 1945 graduate of Swiss Federal Institute of Technology.

William A. J. Mitchell, President, Central States Engineering, Inc., Appleton, Wis., a 1938 graduate of the University of Wisconsin.

E. H. Muntinga, Director, Cooperative Strawboard Mill, De Endracht, Appengedam, Holland, a 1926 graduate of Agricultural University, Holland.

Robert A. Negaard, Chemist, Paper Div., Continental Can Co., Utica, N. Y., a 1949 graduate of New York State College of Forestry.

Ralph O. Phillips, Vice-President in charge of Mill Operations, Chemwood Corp., Manchester, N. H., a 1915 graduate of Tufts College with an M.S. degree in 1916.

John H. Purse, Librarian, Carbide and Carbon Chemicals Corp., South Charleston, Va., a 1929 graduate of the University of Virginia.

Kenneth L. Rawlinson, Laboratory Technician, Burroughs Adding Machine Co., Detroit, Mich.

John F. Reid, Sales Promotion and Technical Development, Spencer Kellogg & Sons, Ind., Decatur, Ill. Attended the University of Buffalo.

Curt Rosenblad, President, Rosenblad Corp., New York, N. Y., a 1923 graduate of Technical University, Stockholm, Sweden.

Alfred L. Saindon, Jr., Bar Mills, Me., a 1949 graduate of the University of Maine.

William Schoenberg, Sales Agent, Lord & Schoenberg, Cleveland, Ohio. Attended the University of Chicago.

Frederick L. Schucker, Chief Chemist, Hercules Powder Co., PMC Dept., Parchment, Mich., a 1943 graduate of Franklin & Marshall College.

Lloyd H. Silvernail, Chemist, Dow Chemical Co., Midland, Mich., a 1942 graduate of New York State College of Forestry.

Jack P. Smallridge, Research and Development, Paper and Cardboard Products, The Metal Box Co. Ltd., London, England, a graduate of Merchant Venturers Technical College, Bristol.

William S. Spiller, Materials Control Engineer, Marinette Paper Co., Fort Edward, N. Y., a 1948 graduate of Massachusetts Institute of Technology.

Henry R. Stevens, Production Manager, The Flintkote Co., East Rutherford, N. J., a 1933 graduate of Syracuse University.

Alvar A. Svens, Research and Development, Fitchburg Paper Co., Fitchburg, Mass.

David P. Thomas, Instructor of Wood Technology, New York State College of Forestry, Syracuse, N. Y., a 1941 graduate of the University of Washington with an M.F. degree in 1947.

David R. Wadleigh, Project Engineer, Scott Paper Co., Chester, Pa., a 1938 graduate of Massachusetts Institute of Technology.

Ian Watson, Student, New York State College of Forestry, Syracuse, N. Y.

TAPPI Notes

George A. Balko, formerly of the Mead Corp., is now Resident Manager, Southern Division, Hudson Pulp & Paper Co., Palatka, Fla.

T. Cathinco Bang is now Office Manager, A/S Tofte Cellulosefabrik, Oslo, Norway.

Arne Berglund is now President of Fylgid Printing Co., Stockholm, Sweden.

Henry G. Booth, of the Robert Gair Co., has been transferred from Bogota, N. J., to the Research Laboratory, Uncasville, Conn.

Edward F. Boyle is now Asst. Superintendent, Bloomer Bros. Co., Newark, N. J.

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Robyn A. Campbell is now Asst. Director of Research i/c Pulp and Paper, Minnesota & Ontario Paper Co., International Falls, Minn.

Edwin C. Daniels, formerly of the New York State College of Forestry is now Chemist for Texon, Inc., S. Hadley Falls, Mass.

Myron F. Flotow is now Paper Production Manager, Central Paper Co., Muskegon, Mich.

John J. Graham is now Hard Board Superintendent, Associated Pulp and Paper Mills Ltd., Burnie, Tasmania.

Robert P. Green, formerly student, New York State College of Forestry is now a Technician in the Research Laboratories, Champion Paper & Fiber Co., Hamilton, Ohio.

Martin H. Gurley, Jr., formerly of Gustavus J. Esselen, Inc., is now Research Director, American Textile Co., Inc., Pawtucket, R. I.

Gerald W. Hough, formerly student, New York State College of Forestry is now Chemist, Weyerhaeuser Timber Co., Pulp Div., Longview, Wash.

Robert E. Ingison, formerly student, New York State College of Forestry is now Chemist, Champion Paper & Fibre Co., Pasadena, Texas.

Erland F. C. Kiosterud, Jr., is now Secretary, A/S Krogstad Cellulosefabrik, Mjondalen, Norway.

Theodore E. Kloss, formerly of the Ryegate Paper Co., is now Technical Superintendent, Hollingsworth & Whitney Co., Waterville, Me.

Charles M. Koon, formerly of the Munising Paper Co., is now Asst. Head, Pulp, Paper & Timber Unit, Office of Special Representative, Paris, France, and Dept. of State, Washington 25, D. C.

O. B. Mason, formerly of the Escanaba Paper Co., is now on the staff of the Vice-President, Mead Corp., Chillicothe, Ohio.

Alfredo M. Mastrokalo is now Technical Adviser, Corp. Peruana Del Amazonas and Professor of Chemistry, Escuela De Ingenieros de Lima, Lima, Peru.

D. Chace Mather, formerly of the St. Regis Paper Co., is now Technical Director, Carthage Paper Makers, Inc., Carthage, N. Y.

George H. McGregor is now Supervisor of Pulp, Paper and Byproducts Research, Minnesota & Ontario Paper Co., International Falls, Minn.

L. Morris Mitchell, Consulting Engineer, has moved to Room 1003, 10 East 39th Street, New York 16, N. Y.

Carl Moe, formerly of the Stevens Point Pulp & Paper Co., is now a Consulting Industrial Chemist, 18 Phipps Ave., Rice Lake, Wis.

Pierre Mougeot, formerly of Milton Hersey Co., is now Chemist, Johnson & Johnson, Ltd., Montreal, P. Q.

Jerrold H. Moyer, of the Champion Paper & Fibre Co., has been transferred from Hamilton, Ohio, to Pasadena, Texas as Technical Adviser.

Edward K. Nissen, formerly student, New York State College of Forestry is now chemist, Camp Mfg. Co., Franklin, Va.

P. A. Nussbaumer, Technical Director of the Pollock Paper Co., has been transferred from Columbus, Ohio, to Middletown, Ohio.

Paul L. Onash, Research and Technical Director, Arkell Safety Bag Co., has been transferred from New York City to Newport News, Va.

Edward B. Osborne, Technical Service Engineer, B. F. Goodrich Chemical Co., has been transferred from Cleveland, Ohio, to 475 Fifth Ave., New York, N. Y.

Ward Pigman, formerly of the Institute of Paper Chemistry, is now Associate Professor, The Medical School of Alabama, University of Alabama, Birmingham, Ala.

H. T. Randles is now Chief Chemist, Paper Div., St. Regis Paper Co., Tacoma, Wash.

Jesse M. Robinson, Chemist, Champion Paper & Fibre Co., has been transferred from Canton, N. C., to Hamilton, Ohio.

Augustus W. Rocker, formerly of the Morris Paper Board Co., is now with the American Writing Paper Co., Gill Div., Holyoke, Mass.

D. F. Sampson has been transferred from San Francisco, Calif., to Maywood, Ill., where he is Chief, Container Research Section, American Can Co.

Frederick N. Sprague, of the St. Regis Paper Co., has been transferred from Bucksport, Me., to New York City where he is Manufacturing Representative of the Eastern Division.

Robert A. Springer, formerly of The Cowles Co., is now in the Technical Service Div., Diamond Alkali Co., Painesville, Ohio.

Edward J. Stevens is now Chemist for the Irvington Varnish & Insulator Co., Newark, N. J.

James E. Sullivan is now Technical Director, McLaurin-Jones Co., Brookfield, Mass.

Alexander Szwarc, formerly of The Arborite Co., Ltd., is now Consulting Chemist, Cellulose Assets Development Co., Montreal, P. Q.

V. Edwin Ware, formerly of the Tarentum Products, Inc., is now Project Engineer, Rust Engineering Co., Pittsburgh, Pa.

Wesley O. Wilkinson, formerly of the Personal Products Corp., is now Production Superintendent, Johns-Manville Corp., Tilton, N. H.

Edward C. Willcox, formerly of Pacific Mills, Ltd., is now Chemist, Nanaimo Sulphate Pulp Co., Harmac, B. C., Canada.

William R. Zwecker is now President, Saugerties Paper Mills, Saugerties, N. Y.

Industry Notes

The Grand River Paper Co., is now known as the McLaurin-Jones Co., Grand Rapids Div., Grand Rapids, Mich.

* * *

Wallace W. Weber has retired after 36 years of service as Chief of the Division of Information and Education of the Forest Products Laboratory, Madison, Wis. Practically every published article originating at the Laboratory and appearing in *Tappi* and other magazines were prepared by Mr. Weber. He is succeeded by Donald G. Coleman who has been staff editor at the Laboratory for the past 21 years.

* * *

J. C. Lathrop has been elected President of the Cameron Machine Co., 61 Poplar St., Brooklyn, N. Y., to succeed the late Harold Kinsey.

* * *

The Solvay Sales Div., has just issued a new edition of their Technical and Engineering Service Bulletin No. 7, Liquid Chlorine, 60 pp. illustrated. Users of chlorine should send for this bulletin. Write to Solvay Sales Div., Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y.

* * *

Contracts covering more than 1½ million dollars worth of papermaking equipment have been signed by the Sandy Hill Iron & Brass Works and the firm of Cartiere Burgo of Milano, Italy, both TAPPI members. This will provide 125 days work for 400 people at Sandy Hill.

* * *

C. G. Bennett, Manager, Paterson Pacific Parchment Co., Coating and Laminating Dept., San Francisco, Calif., a TAPPI member, has developed a new package for holding

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celery in shape during shipment. He also developed water insoluble inks and heat-sealing components for this novel package.

Howard L. Vincent

Howard L. Vincent, President of George Vincent, Inc., New York, N. Y., was killed in an automobile accident on July 21, 1949, while vacationing with his wife in Cape Breton. His wife was uninjured.

Mr. Vincent was born in Berkeley, Calif., on June 25, 1908 and attended Columbia University. For the past twenty years he has been Director of Research of his company which manufactures tracing papers. In 1942 he became President of the company.

He is survived by his wife, Miriam S. Vincent; his daughter, Stephanie; his father, George Vincent; a sister and a brother.

S. B. Bugge

Sven B. Bugge, former President of the Tamahawk Kraft Co., now The National Container Corp. of Wisconsin, died at his home in Tomahawk, Wis., on August 9. Mr. Bugge was born in Larvik, Norway, on Jan. 9, 1878, and graduated from Horten Technical School in 1898. He came to the United States in 1911 as an engineer for the Mosinee Paper Mills. While at Mosinee he built a board mill at Bogalusa, La., and a kraft pulp mill at Ocean Falls, B. C. He engineered and built the Tomahawk Kraft Co. mill and became its general manager in 1924. Mr. Bugge was a member of the Technical Association of the Pulp and Paper Industry since 1926.

EMPLOYMENT SERVICE

Positions Open

P27-49. Chemist for plant control and production problems. Kraft mill in Virginia.

P28-49. Paper testing supervisor—man able to accept responsibility and direct research in the field of paper testing. Prefer engineering or physics degree with experience in this field. Should have definite interest in instrumentation and statistical analysis of test results. Write to The Institute of Paper Chemistry, Appleton, Wis.

P29-49. Pulping research personnel. Prefer graduate chemical engineer with several years of experience in the paper industry. Must be able to plan, supervise, and report research work especially in the fields of pulping, bleaching, and stock preparation. Write to the Institute of Paper Chemistry, Appleton, Wis.

P30-49. Asst. Superintendent between 30 and 45. Cylinder machine mill making roofing felt. East.

P31-49. General superintendent, New York State. Bonds and fine papers.

Positions Wanted

E40-49. Pulp and Paper Technologist-Engineer, B.S. N. Y. State College of Forestry. Three years with pulp and paper machinery manufacturer as Research, Development and Sales, and Service Engineer. Desires responsible position in production, technical, or engineering work.

E41-49. Control Chemist, 9 years' experience, rag and wood pulp papers. Family, college graduate, 35 years old. Prefer location 35 mile circumference of Annapolis, Md. or Washington, D. C.

E42-49. Technical Sales; Chemist, 31, 10 years' experience with cellulose and derivatives, desires technical selling. Excellent health, superior references. Midwest to western territory preferred but eastern offers considered.

LETTERS TO THE EDITOR

Preservation of Groundwood Pulp

Ed. Note: In the August issue of *Tappi* is a letter from Mr. Henry Fisher of Westcott & Mapes, New Haven. Conn. This commented on the paper by B. F. Shema, "Preservation of Groundwood Pulp During Storage," which appeared in the May issue of *Tappi.* Following is a response received from Dr. Shema of the Institute of Paper Chemistry:

To the Editor of *Tappi:*

"I was very glad to receive the comments of Mr. Fisher and I believe that comments of this type should be encouraged whenever possible.

"Mr. Fisher's criticisms are concerned primarily with the effectiveness of lignasan and not necessarily with the method of application which, incidentally, was the prime purpose of the article. It must be remembered that the types and the population of microorganisms vary among mills. In our particular case we were attempting to control a fungus which had a high degree of resistance to the organo-mercurials. Therefore, in our case, this accounts for the relative inefficiency of the lignasan to prevent the formation of the brown spots.

"In many respects, our data confirm Mr. Fisher's previous experiences in the field of pulp preservation. Figure 2 in my article on pulp preservation shows the condition of the pulp after 6 months' storage. It can be seen that lignasan preserved the pulp, except for the formation of a few brown specks which were caused by the mercury-resistant fungus."

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Calendar of TAPPI Meetings

NATIONAL

Fourth Engineering Conference of the Pulp and Paper Industry, Statler Hotel. Boston. Mass., October 31, November 1–3, 1949.

Fibrous Agricultural Residues Conference, Terre Haute House, Terre Haute, Ind., November 7–8, 1949.

Fundamental Research Conference, Chateau Frontenac, Quebec, P. Q., May 29–30, 1950. Symposium: "The Papermaking Properties of Fibers."

LOCAL SECTIONS

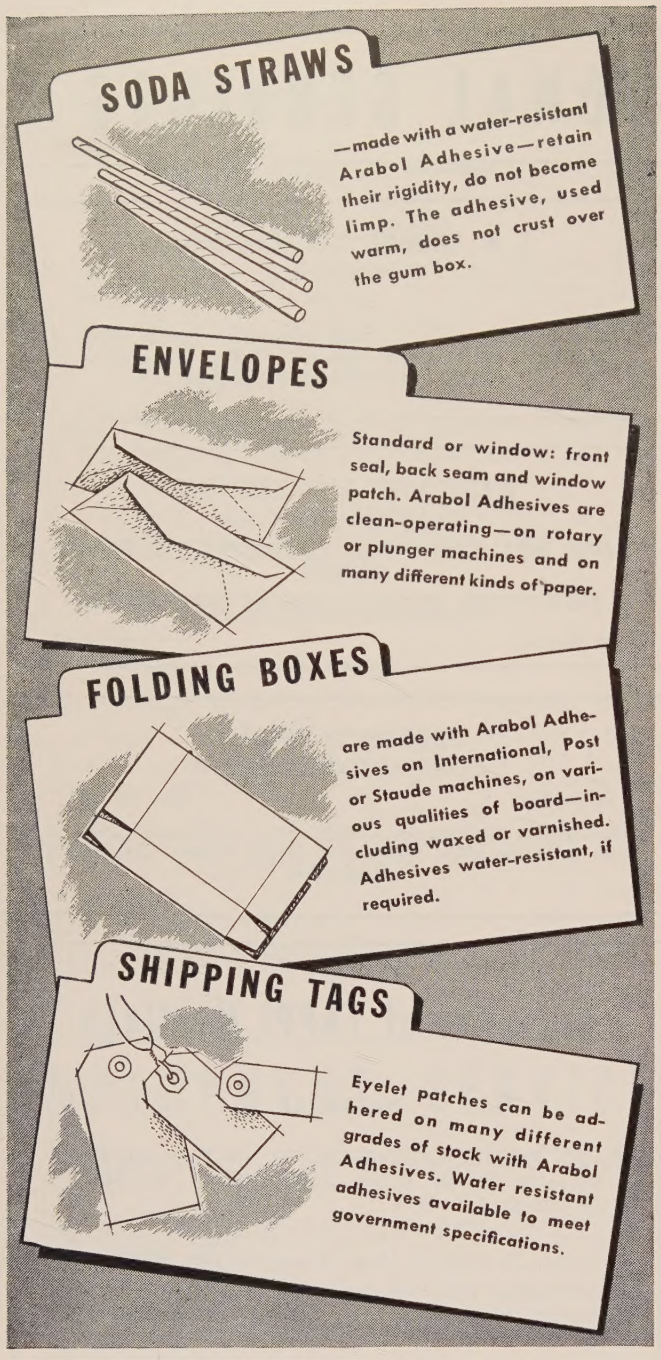
Delaware Valley Section: September 30, 1949, P. H. Glatfelter Co., Spring Grove, Pa. 5:00 p.m. Mill Visit—2:00 p.m. Dinner Speaker—E. W. Clem, Rice Barton Corp., Worcester, Mass. "New Paper Machine Developments."
October 27, 1949, Engineers Club, Philadelphia, Pa.

Ohio Section: October 13, 1949, Manchester Hotel, Middletown, Ohio. Speaker—Allen Abrams, Vice President, Marathon Corp., Rothschild, Wis.

Maine–New Hampshire Section: October 21–22, 1949, Lafayette Hotel, Portland, Maine. Panel Discussion on Paper Reinforcers. 2:00 p.m. October 21, 9:00 a.m. October 22.

Pacific Section: October 25, 1949, December 6, 1949.

Lake Erie Papermakers and Converters Association: October 7, 1949 at 6:30 p.m. Hickory Grill, 929 Chester Ave., Cleveland, Ohio. Subject—"Paper and Paperboard Finishes."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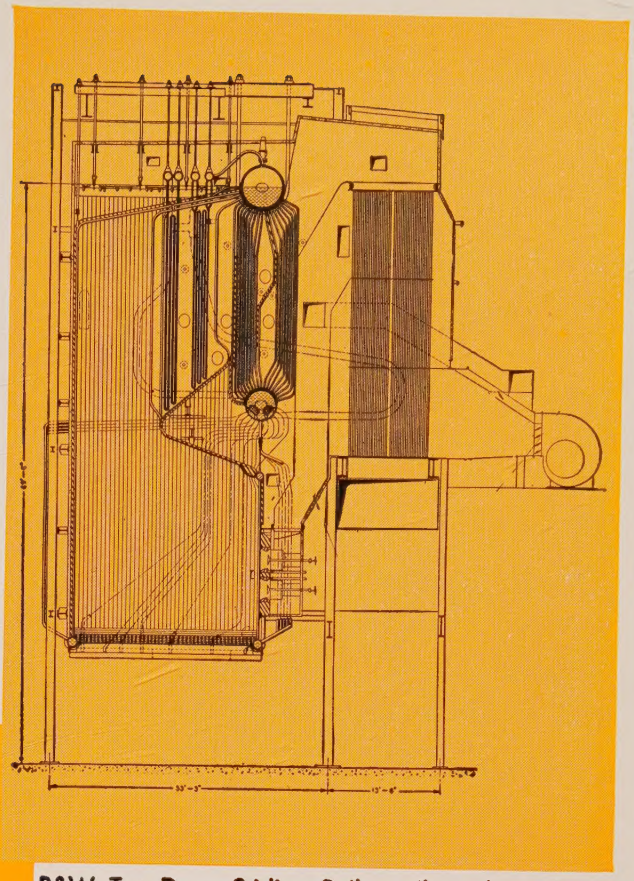
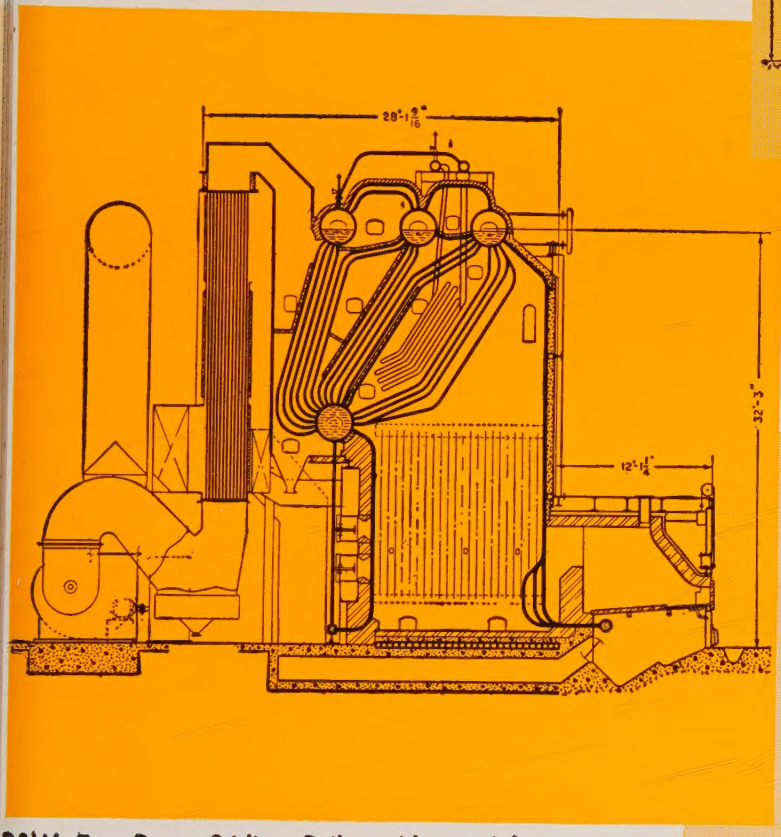
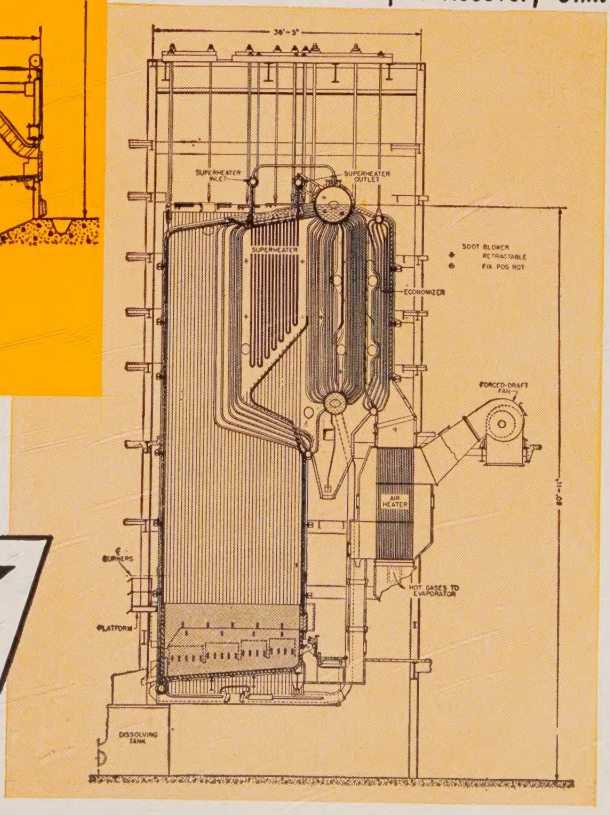


B&W Two-Drum Stirling Boiler, oil- and gas-fired. Also available in four-drum and integral-furnace types.



B&W Four-Drum Stirling Boiler with special bark furnace. Also available in two-drum types.

B&W Black Liquor Recovery Unit.



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